DESIGN ASSISTANCE FOR NEW COMMERCIAL BUILDINGS: MODELING FOR ENERGY EFFICIENCY

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ABSTRACT

The Design Assistance for New Commercial Buildings program, sponsored by the Bonneville Power Administration, began in November 1986. The goals of the program are to:

1. Determine how commercial owners and their design teams make decisions about energy efficiency for their buildings;
2. Increase energy awareness among commercial builders and designers during the design process;
3. Discover if builders will install cost-effective, energy saving improvements without financial incentives; and
4. Collect data on the estimated energy savings of recommended energy efficiency strategies in these new buildings.

To accomplish these goals, expert energy consultants work directly with the owners and their design teams on the design of commercial building projects. They first define potential energy saving strategies. Then, the consultants use computer models to show the incremental energy and cost savings of various design options. They model strategies such as HVAC design and control, building envelope upgrades, lighting strategies, and fenestration. The service is free.

Each owner receives a report describing which energy saving measures are most cost-effective. In some buildings, initial capital investment can be reduced through more appropriate equipment sizing. Owners choose whether to install any or all measures.

This paper is based on program records, staff observations and the results of an independent evaluation of the first 21 projects completed under Design Assistance. The evaluation uses interviews with the consultants,the owners, and their design teams, and looks at both process and outcome issues.

The evaluation profiles participants, their reasons for participating and their perceptions about program strengths and weaknesses, the types of projects and energy strategies involved, program marketing, and the role of the energy consultants. It analyzes preliminary energy outcomes as well as the awareness and education effects of the program on the participants.

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BACKGROUND

Since November 1986 the Washington State Energy Office (WSEO) has provided Design Assistance for New Commercial Buildings. Design Assistance, funded by the Bonneville Power Administration, matches commercial developers and their design teams with energy consultants who are experts in computerized energy modeling and energy-efficient building design.

These experts, hired by the program, work directly with project decision-makers to analyze energy use, and to identify and recommend energy saving strategies in the proposed buildings. Energy Office staff oversee project progress and review final reports for accuracy and completeness. Participants are not required to install recommended energy strategies but are asked to seriously consider them. Participants finance any strategies which they decide to implement.

In this paper we describe:

1. Program Goals
2. The Design Assistance Process
3. An Evaluation of Design Assistance
4. Energy Strategy Modeling Results
5. Recommendations

PROGRAM GOALS

The goals of Design Assistance are to:

1. Examine how participants make decisions about incorporating, or not incorporating, energy-efficient design strategies into their new commercial buildings.

2. Increase the understanding of participating commercial building owners and their design teams about the benefits of energy saving design strategies for their new commercial buildings.

3. Discover if participants added recommended energy saving strategies due to Design Assistance.

4. Discover if participants, without Design Assistance, are likely to continue to consider and/or install energy saving strategies for new commercial projects.

5. Collect preliminary data on the estimated energy savings of recommended, planned for, and installed energy-efficient strategies in participating commercial buildings.

THE DESIGN ASSISTANCE PROCESS

Process Overview

WSEO streamlined the Design Assistance process so that the services could match the existing time line of the project developer. The process can be summarized as follows:

1. Design Assistance request comes in.
2. Project is screened for preliminary appropriateness based on building size, type, location, and project timeline.
3. Initial or "scoping" meeting is established with the design team, the energy consultant, and the program coordinator.
4. Initial set of energy strategies is developed for modeling.
5. Consultant develops scope of work, budget, and timeline.
6. Scope of work is negotiated and the budget and timeline are finalized.
7. Consultant develops and presents base case computer model to design team. Strategies are reviewed and modified.
8. Strategies are evaluated and final report is presented to project design team.
9. Design team reviews final report and adopts or rejects recommended measures.

During the process the consultant interacts with the design team to gather necessary information and to keep them informed of his progress. The process involves continual interaction between the design team and the consultant, while the program coordinator acts as a troubleshooter and monitor to keep the process moving forward.

Initial Meeting

When developers or A/E firms contact WSEO about Design Assistance, we gather information on the project, including the building type and size, project design team members and the building development timeline. Projects are then screened for suitability. Projects are deemed suitable if the development timeline will allow for modifications to the original design and they meet a minimum size guideline of 10,000 square feet. The reason for the minimum size criteria is to help assure overall cost effectiveness for the program with respect to potential energy savings. If we identify the project as suitable, a scoping meeting is then held where the design team meets with the consultant and the WSEO program coordinator.

At this meeting we try to clearly identify the roles of WSEO, the owner and his design team, and the energy consultant. We stress that the owner and design team will work directly with the energy consultant, but that WSEO will monitor the project and help out if problems arise. The role of the owner and his design team is to provide information to the consultant and to seriously consider energy options.

We especially emphasize that the consultant's work supplements the normal design process since he can more thoroughly develop and evaluate energy options than most A/E fees can justify. The design team's initial acceptance of the consultant as a competent professional is crucial to smooth project progress and to the team's eventual willingness to accept the consultant's final package of recommendations.

With this in mind, the consultant's first responsibility is to explain the modeling process, to discuss the computer energy simulation program that will be used, and to solicit input from the design team. This input includes information on construction costs for various building components. When provided by the design team, this information helps ensure an accurate economic analysis.

The next task is to begin to develop a list of energy-related strategies that the modeling contractor will analyze. The consultant brings to the process a background in energy-related design and thus is able to suggest a number of measures to investigate. The design team itself may have many ideas it wishes to have analyzed. Together the players develop a plan for optimizing the energy efficiency of the building based on the developer's own economic criteria.

The economic analysis developed for the building owner may take many forms. It may involve evaluating the economics of the measures using simple payback, internal rate of return, life cycle costing, or other methods. To be useful and persuasive, the analysis must be based on the actual criteria normally used by the building owner in making economic decisions.

For instance, depending upon the developer's business situation, first cost or long-term cost of operation may be the most important consideration. If the developer will be a tenant in the building, long-term operation and maintenance costs are more often considered when determining what kinds of measures are cost effective. If the building will be leased with outside firms occupying it, the first cost of construction has a greater influence on the owner's decisions regarding expenditures for energy efficiency.

Developing the Baseline

The first working task of the energy consultant is to develop a base case against which the various energy measures can be compared. The base case is developed using one of a number of computer based, energy simulation programs. The particular model chosen depends upon the complexity of the building being modeled, the kinds of energy efficiency measures investigated, and the experience of the consultant.

Energy simulation programs are divided into two categories: modified bin models and hourly models. The bin models are easier to use, but have limited accuracy and can be used to model only some kinds of systems within a building. Hourly models are more complex, requiring a greater number of inputs but result in more accurate estimates of building energy usage. Because of this, hourly models are used on large buildings that contain many distinct areas or zones.

The base case model can be of the proposed building, as originally designed, or a modified version of the building that complies with the State Energy Code. Ideally, the model would then be compared to a similar facility which already exists and for which utility records are available. This is most easily done for chain stores or other multiple facility businesses. Comparison of utility records allows the consultant to "calibrate" the baseline model. Calibration increases the accuracy of the model by comparing predicted energy use against a known reference. Modifications to the model can be made at this point if significant differences exist. If such a reference building does not exist, a quick check of the baseline energy utilization index (EUI) can be made to compare the model with EUI's of buildings with similar design and occupancy.

A "baseline meeting" is then held to bring together the consultant and the design team to discuss assumptions used in development of the base model. This is an important step because it provides the consultant an opportunity to verify the inputs for the computer simulation. The design team can confirm or modify the basic assumptions about building configuration, occupancy, and operation. Once the baseline is established, evaluation of the energy strategies can begin.

Strategy Analysis

Strategies are analyzed for the major end-use functions of the building. Building envelope, lighting, HVAC, and domestic hot water are the end-uses most often modeled. Within the end-uses several levels or kinds of measures can be investigated, depending upon the wishes of the design team and the consultant. Where the building shell has been designed to meet existing codes, installation of insulation beyond code requirements is examined. Various glazing options can be analyzed as well. The window-to-wall ratio may also be evaluated along with other architectural components such as overhangs and orientation.

Lighting designs can be evaluated with both light source and controls providing opportunities for savings. Where natural light is available, the consultant can investigate daylighting control options for use within the buildings.

Commonly, the largest energy end-use in commercial office buildings are interior lighting or space heating and cooling. Thus, nearly every Design Assistance report includes an analysis of several of the HVAC systems and controls available. Most Design Assistance studies are fuel blind, in that, where available, several fuel sources are investigated to determine which one is most economic for the particular building evaluated. The fuel selected for space heating can greatly influence the attractiveness of other measures analyzed.

Simultaneously modeling several measures to determine interactions can be enlightening to both the developer and the consultant. Completed Design Assistance studies have shown that envelope measures that are cost effective for one space heating fuel are not cost effective when a different fuel is chosen. Thus, it is important that the building be modeled as a complex unit rather than a simple sum of many parts.

The Final Report

Presentation of the final report offers the last opportunity for the modeling contractor to sell the value of the energy efficiency strategies recommended. This is the last formal meeting between the consultant and members of the design team. The consultant's job here is to clearly summarize the results of the modeling efforts for the developer. He has gained the confidence of the project design architect and engineer by that time and must transfer that confidence to the developer as well. The developer and his design team then decide the final building design.

EVALUATION OF THE DESIGN ASSISTANCE PROGRAM

Twenty-one Design Assistance projects—those undertaken in the first year of program operation—were the focus of a program evaluation. A consultant studied program records, discussed program progress with program staff, and conducted 62 in-depth interviews with participants and energy consultants. The results evaluate program steps and examine whether Design Assistance effected positive changes in energy behaviors and awareness.

The approach provides a comprehensive view of each project and of the overall program during the first year of operation. However, the number of projects is small and how representative they are of others yet to participate in Design Assistance is not easily determined. In addition, due to the time lag between Design Assistance services and construction, only preliminary information is available about which energy saving strategies were actually installed.

Research Questions

The research addressed these core questions:

1. How successfully did Design Assistance foster energy-efficient design and the installation of recommended strategies?

2. How did Design Assistance affect participant appreciation for and understanding of energy-efficient design strategies?

3. How did participants react to the services they received? How would they like those services improved?

4. What factors appear essential to program success? What factors may limit the program?

Key Evaluation Findings

Energy Outcomes. Design Assistance successfully identified energy saving strategies in the projects it attracted. For the 21 projects (22 buildings), consultants recommended 95 energy saving strategies—an average of 4.3 strategies (with a range of 1 to 13 strategies) per building. They most often recommended heating and ventilation (33 percent) and lighting (28 percent) improvements.

At the time of the interviews, most developers thought they would install one or more of the recommended energy saving strategies. At least one additional energy saving strategy was likely to be installed in 86 percent of the buildings, with two or more strategies likely to be installed in 45 percent. Of all the strategies recommended, about half (46 percent) were very likely to be installed.

The program effectively influenced energy-efficient design. Seventy-seven percent of participants said the program influenced them to seriously consider or to install one or more energy saving strategies in the Design Assistance project.

When asked if the program would affect how they did business in the future, 94 percent said it would and discussed a variety of effects. They said they would incorporate successful energy-efficient strategies into future buildings and use the analysis as a way to document decisions. They also reported they could use their experience as a marketing tool to enhance their qualifications, and as support for a more thorough energy analysis. Almost half (49 percent) said they would participate again in Design Assistance, and 23 percent said they might try to persuade clients to pay for energy modeling.

Energy economics were not the only barriers to installing strategies. Although the most common reasons not to install measures had to do with the costs of the strategies (payback, up front costs, costs to change), other barriers included uncertainty about the technology, maintenance problems, aesthetics, comfort, a bad fit with other systems, and potential negative effects on business (e.g., reduced sales from lighting changes in a retail store).

Education and Awareness Outcomes. Design Assistance met its goal of increasing the energy awareness and knowledge of the participants. The vast majority—81 percent—of the 36 participants reported they increased their knowledge of energy-efficient design. Educational benefits included project specific improvements, introduction to new strategies, better familiarity with computer modeling, and verification or rejection of prior energy saving hunches and practices.

Many participants especially noted the benefits of receiving hard numbers to confirm already sound energy decisions. Precise information could then be used to more effectively sell energy ideas to owners or management. The energy analysis often proved to be an effective decision-making tool.

Participants felt the larger design community would benefit from information about Design Assistance projects and findings. They suggested Design Assistance could broaden its effects by distributing well-documented results, especially to design professionals.

The energy consultants who participated in Design Assistance also felt they had increased their expertise and improved their services. Consultants reported they improved aspects of their consulting approach—both technical and communication skills—due to experiences with design assistance projects.

Program Satisfaction. Overall satisfaction with Design Assistance is high. Sixty-nine percent of participants were very satisfied with the program and 28 percent were somewhat satisfied; only 3 percent were not satisfied with the services they received. Energy Office staff received 100 percent excellent or good marks, especially for delivery of a low red tape service.

Consultants received 97 percent excellent or good ratings. Participants particularly praised consultants for their precise information and recommendations, and for their responsiveness and professionalism throughout the process.

Major reasons for dissatisfaction were breakdowns in communication between consultants and participants, strategies that did not work, and information that was received too late.

Five factors emerged as crucial to the projects that participants rated as highly successful:

1. Early entry into the program—at the design development phase—before too many decisions had been made (unless the project is a prototype building and the design will be used for future buildings).

2. Consultants who received high marks for both technical and communication skills.

3. A concise final report with clear recommendations.

4. Participants who felt they had increased their understanding of energy-efficient design and analysis.

5. Projects with opportunities to implement energy saving strategies.

Program Limits. The success of a design assistance approach is limited by projects with such tight schedules that assistance is not possible, projects with few additional energy savings opportunities, economic and non-economic barriers to implementing strategies (see barriers discussion above), low awareness of the benefits, and the costs of participating.

Participants held diverse opinions about the potential market for design assistance services. While most felt private sector demand was fairly low, others felt it was growing. A major impediment to widespread use, whether services are provided by the public or private sector, is who will pay for the time of design professionals. A well thought out marketing plan would help the present program.

ENERGY STRATEGY MODELING RESULTS

This section provides a more thorough examination of recommended strategies and their potential energy savings.

Lighting Systems

As explained above, strategy selection is based on major energy end-uses. Artificial lighting is an end-use common to all commercial buildings that represents a major fraction of total building energy consumption. Most lighting in today's commercial market is supplied by fluorescent sources. This technology has been in existence since about 1938, and today fluorescent lamps provide about 70 percent of all light generated in North America (IESNA, 1985). Despite recent improvements, the basic technology is little changed since it's origination.

For the buildings in which lighting improvements were found to be cost effective, by far the most common improvement recommended was the use of T-8 fluorescent lamps. The standard fluorescent lamp has a diameter of 1 1/2 inches while the T-8 is a 1-inch diameter lamp. The result is more light output per fixture as compared to conventional lamps.

For the 22 buildings included in the Design Assistance program, 8 reports included a recommendation for use of the T-8 lamp. The average payback calculated in these reports was 5.1 years based on the incremental cost of the lamp and ballast over conventional fluorescent fixtures. As an example, in one major super market participating in Design Assistance, building illumination levels were considered a critical element for merchandising. After some initial skepticism, the store's design team accepted the T-8 system as a cost-effective alternative to conventional fluorescent lamps that would meet the need for quality light and provide a payback of 4.5 years.

Heating, Ventilating and Air Conditioning

Depending on the specifics of a commercial building, either lighting or heating, ventilating and air-conditioning (HVAC) will be the major energy consuming end-use. The lighting industry, being aware of this, has spent considerable effort in developing new technologies to serve the commercial sector. As a result, the same cost-effective lighting strategy was recommended again and again in many Design Assistance studies. The same cannot be said, however, for HVAC systems. Different building uses yield different space heating and cooling needs. While cost-effective HVAC strategies were recommended for about a third of all the buildings worked with, few of these strategies could be duplicated from building to building as the T-8 lamps were.

The HVAC strategies recommended ranged from system controls to high efficiency components to natural cooling schemes. The single unifying theme throughout the Design Assistance studies was that, regardless of the system used, effective control is important for energy efficiency. Of the reports completed where HVAC related recommendations were made, fully 50 percent involved controlling HVAC systems or components.

In the larger buildings, variable air volume (VAV) systems were recommended for the control of energy and building comfort. These systems, utilizing either solid state motor control or supply fan inlet vane regulation, vary the amount of air supplied to the building for space conditioning. The reduced air flows result in fan horsepower reductions, saving money on both energy and demand charges.

Recommendations for smaller buildings, with less complex HVAC systems, included precise temperature control with the use of direct digital control (DDC) and variable volume, variable temperature (VVVT) systems. DDC and VVVT systems control space temperatures with the aid of micro-computer based logic.

In many buildings, large and small, natural cooling systems were investigated. HVAC system economizers were recommended for 3 of the 22 buildings in the program. Economizers introduce outside air into the building when ambient temperatures are low enough to provide the necessary cooling. This eliminates the need for mechanical cooling during moderate weather conditions which are experienced during much of the year in the Pacific Northwest. An evaporative cooling system was recommended as an economical means of maintaining building comfort for one small bank building with modest computer loads.

The final computer analysis report delivered to the developer is one part of the total impact the Design Assistance program makes in the Pacific Northwest. Involvement by the design team in energy modeling and heightened awareness of energy simulation as an effective design tool is another impact. The ultimate goal is to positively affect the commercial building sector in this region. This sector now accounts for 20 percent of the Pacific Northwest's total electricity sales or about 26 billion kWh/yr (NPPC, 1986). This share is expected to grow faster than that of any other sector over the next 20 years. Design Assistance will help control that growth by encouraging construction of structures that are economical and energy efficient.

RECOMMENDATIONS

Overall, the Design Assistance services provided by the Washington State Energy Office have resulted in additional energy saving strategies being implemented and in increased knowledge about energy efficiency among participants. The following recommendations are pertinent to the success of similar types of programs.

1. Deliver the most streamlined, low "red tape" services possible. Timeliness and lack of bureaucracy are critical to success and reduce the time investment of participants.

   Design Assistance was frequently complimented for being an atypical governmental program. The low bureaucracy, flexible approach not only builds credibility in the private sector, but also is responsive to the time demands of the projects. The program must go at the projects' pace—whether that means speeding up or slowing down activities. Participants cannot be relied upon to be flexible.

2. In general, select projects that can enter into the program at an early stage, before critical and irreversible design decisions have been made.

   Unless the project is for a prototypical building, the ideal time for most projects to enter Design Assistance is after preliminary design work has been done but before too much investment—both psychological and monetary—has been made. (It is possible, however, for a project to enter too early so that there are too many possibilities.) While it is difficult to exclude projects that would like design assistance, the prospects for a successful project are greatly diminished if the assistance is provided too late in the project.

3. Try to screen out projects that do not have any viable energy saving opportunities.

   Data strongly suggest that participants want to have at least one viable energy saving opportunity as a reward for their investment of time. While increased understanding and confirmation of experience are important (see next recommendation), actual energy saving opportunities are a crucial factor in participant satisfaction.

4. Realize the value of Design Assistance as a "confirmation" tool, as well as a "innovation" tool.

   Time and again, participants mentioned that Design Assistance analysis provided them with objective "hard numbers" that they could use to justify existing recommendations to owners or to test their hunches. This does not replace the discovery of new cost-effective strategies, but it can be important to future activities of the participants.

5. Use consultants who both understand the technical aspects of energy analysis in new commercial buildings and have strong communication skills. Sensitivity to the dynamics of the owners and their design teams is crucial.

   The importance of good consultant performance cannot be underestimated. Technical competence must be coupled with project management skills. Much existing consultant experience has been with retrofit of buildings, and new commercial buildings offer increased challenges. The role of the consultant is a precarious one. It involves balancing sales of energy-efficient strategies with the practical realities of commercial practices and design team structure. Team structures where the owner or developers are highly involved with Design Assistance may be the most challenging since the skills of design team members are open to close scrutiny from the ultimate decision-maker. Good judgment and common sense are essential.

6. Use a consistent marketing approach, concentrating on reaching design professionals who can sell the idea to project owners, and using themes suggested by participants.

   The first year of the Design Assistance program was fraught with many changes that affected marketing efforts. Both to reach a wider audience of potential participants and to measure marketing effectiveness, a well defined marketing strategy should be developed and implemented. These themes should be emphasized: long-term savings opportunities, low red tape, higher quality buildings, a competitive edge for design teams, and the value of energy analysis as a decision-making tool.

7. Distribute the results of successful design assistance efforts to the larger design community.

   Participants in this program felt that other design professionals would pay attention to well documented success stories from the Design Assistance program. While many design professionals may not have the ability to participate, they can benefit from the experience of others. With such a highly educated group—and one interested in staying current with the best building methods and increasing their competitive edge—such informational activities would be worth the investment of the sponsoring agency.

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