Incentive Program for Energy Efficient Design of State Buildings

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ABSTRACT

In 1996, the State of Utah instigated a pilot program intended to improve the energy efficiency of newly designed State buildings. The goal of the program was to show that buildings could be designed to be more energy efficient than the State's energy code, ASHRAE/IES 90.1 without adding to the construction costs. Four of the eight buildings beat the code by at least 50%; one by 40% and one by only 22%. One project is still in design.

This paper summarizes the program's design, implementation and results through May 31, 1998. It presents an informal evaluation and discusses program highlights - both positive and negative. The difficulties - both technical and political - in using the ASHRAE Standard for Energy Efficient Design of New Buildings (ASHRAE/IES 90.1) in an incentive-based program are discussed. Possible solutions to specific problems are presented. The impact of incentives on the design teams, their methods and the resulting design are also discussed.

Introduction

This paper describes a pilot program in which the State of Utah offered an incentive award to design teams to encourage energy efficient design of eight new or extensively renovated State buildings.

At least three aspects set this program apart from most utility-based demand-side management programs: First, a bonus fee is offered to building *designers* by the *owner*, rather than from a utility to a building owner; second, no additional funds are made available for construction costs; third, the *building design* is considered in whole, rather than certain aspects of the building being funded by the incentive. No prescriptive measures qualify for the incentive bonus. The program was designed to encourage thoughtful overall design rather than to finance the installation of efficient components in an ordinary design.

The amount of the incentive was based on the total construction cost of the project and commensurate with energy efficiency. The construction budgets had been previously appropriated and could not be increased. Therefore, the energy efficiency features of the buildings could not add to the cost of the buildings.

This paper was written from the perspective of the Utah Office of Energy and Resource Planning (OERP). For the sake of readability, the plural first person, "we," will be used. "We" refers to OERP, and often includes the Utah Division of Facilities and Construction Management (DFCM) and etc Group, Inc. which was hired to perform energy analyses.

Program Outline

Incentive Schedule

The State of Utah offered the design teams of eight buildings an incentive fee based on the following schedule:

The maximum incentive fee is calculated as 1% of the construction cost. The maximum fee will be paid when the annual energy cost of the building is proven to be less than 51% of the ASHRAE/IES 90.1 energy-cost-budget prototype model. The incentive amount is based on a sliding scale and is paid in two installments. The first installment gives the designers quick reward for good design; the second installment is meant to: 1) encourage designs that are simple for the building users to operate and maintain; 2) persuade the designers to be involved with the installation and commissioning of energy features and the training of building operators.

At the completion of construction documents, the DOE2.1e energy analysis computer program was used to define the following:

$$EC_{proto} = \text{total prototype energy costs - plug load costs}$$

$$EC_{design} = \text{total energy cost of as-designed model - plug load costs}$$

$$\%\ savings_{design} = [(EC_{proto} - EC_{design})/EC_{proto}] \times 100$$

The first installment is based on the following table:

Table 1. % $Savings_{design}$ First Incentive Fee Payment (IFP_1)

Up to:	
25%	(5% of maximum incentive) x 60%
30%	(15% of maximum incentive) x 60%
35%	(25% of maximum incentive) x 60%
40%	(40% of maximum incentive) x 60%
45%	(65% of maximum incentive) x 60%
50 or more	(100% of maximum incentive) x 60%

After one year of operation the energy cost savings are calculated:

EC_{actual} = total actual energy costs - actual plug load energy cost

% $savings_{actual}$= $(EC_{proto} - EC_{actual})(100)/EC_{proto}$

The second installment is based on the following table:

Table 2. % $Savings_{actual}$ Second Incentive Fee Payment

% $savings_{actual}$	Second Incentive Fee Payment (IFP_2)
Up to:	
25%	(5% of maximum incentive) x IFP_1
30%	(15 of maximum incentive) x IFP_1
35%	(25% of maximum incentive) x IFP_1
40%	(40% of maximum incentive) x IFP_1
45%	(65% of maximum incentive) x IFP_1
50 or more	(100% of maximum incentive) x IFP_1

With this payment schedule, the design teams are fully rewarded if the actual building performance is more energy efficient than the computer models predicted. If, however, the building functions less efficiently than anticipated (that is, if IFP_2 is negative), the design team gets no further payment, but is allowed to keep all of the first incentive-fee payment with no penalty.

Determining the Cost Savings with ASHRAE/IES 90.1

Utah has adopted ASHRAE/IES 90.1 as its building energy code. ASHRAE/IES 90.1 includes three methods to use in determining code compliance. Only one, the energy cost budget method can be used to quantify the degree by which a design exceeds the minimum requirements of the code. The energy cost budget method considers the building as a whole in comparison to a model of a code-compliant building. Specific elements, such as air conditioning chillers, are not directly compared.

The energy cost budget method is intended to allow a design team maximum flexibility in meeting 90.1 requirements. In essence, it says, 'Here is the annual energy cost of a building, with a given area and occupancy, designed to meet 90.1 requirements. Design the building any way you want - provided the energy cost is equal to or less than this number.' (See Figure 1) This allows the maximum tradeoff between energy efficient features. A poor envelope can be compensated for by very good lighting and HVAC equipment, or vice versa.

The baseline energy cost budget is established by initial energy analysis of an imaginary building that matches the intended size and function of the building being designed. ASHRAE/IES 90.1 gives guidelines on how to create a computer model of the imaginary building, called either a prototype or a reference building (explained in more detail below). Our program uses DOE2.1e as the analysis tool. The energy cost predicted by DOE2.1e for the prototype building is used as a baseline cost budget. Construction documents are used to create a computer model for the actual building. The resulting predicted annual energy costs predicted by the two models are compared.

Energy loads that are not be influenced by the building's design (such as plug loads) are included in the calculations so that their heat loads are accurately represented in the HVAC energy usage calculations. However, the electricity directly used by these devices is subtracted from the total energy usage of the building so that they do not have an impact on the incentive award calculations.

Modeling Issues

The Role of the Modeling Agent

The modeling agent was hired to produce both the baseline and the as-designed models, using DOE2.1e software. The agent's role was to define the baseline according to the 90.1 ECB method, create the model, and present the results to OERP. The baseline model was based on the building space and programming documents provided to the design team by DFCM.

At first, the modeling agent had no direct interaction with the design team. This was intentional for two reasons. First, we tried to make the program as seamless as possible from the designers' perspectives, so we designated OERP as the only contact for energy related design issues. Second, we wanted the models to be as unbiased as possible, and thought the separation would help accomplish this. After both the baseline and as-designed models were completed, we brought the modeling agent and the design team together to make sure that all the designers' intentions had been modeled accurately.

Prototype vs. Reference

The code has two distinct paths for defining the baseline or ECB model - a prototype model or a reference model.

For the prototype model, the floor areas, occupancy definitions and number of floors as defined by the building's architectural program used to create the model of the imaginary, baseline building. Everything else is prescribed by 90.1 - aspect ratio, orientation, window area and location, u-values, lighting densities, HVAC. system types, and equipment efficiencies. The prototype is not intended to reflect the actual building in either form or performance. It simply predicts the energy costs of a code-complying building of the same size and function.

On the other hand, the reference building model has similarity to the actual building. The designed shape and orientation of the building are used, and the designed HVAC. systems and thermal zoning are also used. The reference building model is used when the actual building's function cannot be represented by a combination of the building types listed in 90.1, when the standard occupancy or use-profiles cannot be altered to represent the proposed design, or when owner or site requirements force a particular form or orientation.

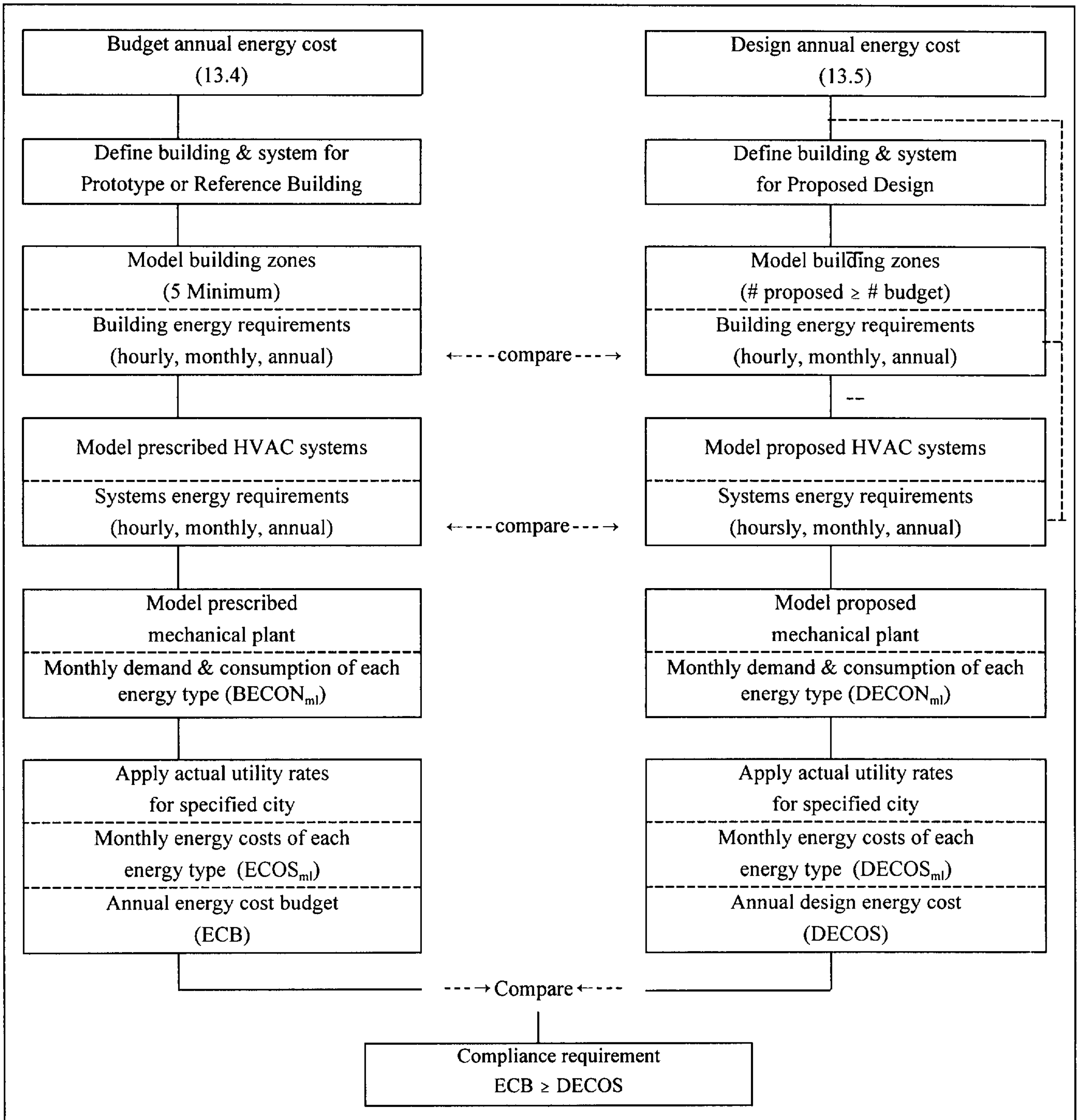

Figure 1 Compliance Schematic for the Energy Cost Budget Method[1]

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[1] American Society of Heating, Refrigerating and Air Conditioning Engineers, *ASHRAE/IES Standard 90.1-1989 User's Manual*, 1992, 13-2.

Interpretation

The 90.1 code clearly wasn't designed for this type of incentive program. It is a pass/fail test and as such works well. Things get tricky when it is used to measure relative performance. Since the incentive payment is based on relative improvement, the designers were understandably concerned about issues that they either had no control over or were by nature, subject to interpretation by the modeler.

One issue is choosing to use a prototype model or to use a reference approach. This seems straightforward but, in the context of this program, it is not. For example, we initially modeled a forensics hospital using the health/institutional prototype. However, the building's owner required a window in every patient room. When combined with the required number of rooms, common area and site plan, the designer was forced to use a complicated envelope that increased the wall to floor area ratio. The designers felt that they were starting at a disadvantage. A strict interpretation of the standard would say too bad - use a prototype model. However, since this was beyond the designer's control, we chose to remodel the baseline using the reference building approach.

Another problem: once the reference method is applied, what about the HVAC. equipment? Do the prototype systems and performance still apply? Alternatively, should the model use the systems as selected by the design team? The standard is not clear about what is meant by HVAC. system type. In one sentence, it says, "... the HVAC system and zoning shall be as in the proposed design." In the very next sentence it states, "all other characteristics such as ... HVAC system shall meet the requirements of Section 5 through 12."

This was a significant issue in the chemistry building. Since a large part of the floor space was classified as laboratory, which doesn't really fit the health/institutional category, the reference approach was used. In the actual design, the HVAC systems had six inches of static pressure on both supply and return. Under one interpretation, the reference model should use 6" for the supply and 6" for the return/exhaust ("... HVAC system shall be as in the proposed design"). Under another interpretation, the supply static would be 3" and the return static 1"[2]. The difference is significant. We ended up using 6" because, as designed, the system required 6". (See "Bias Toward Success" below.)

Evaluation and Results

Conclusions

The following table summarizes the results of the program: As the table shows, of the seven models completed, four have energy costs of at least 50 per cent less than allowed by the state energy code.

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[2] American Society of Heating, Refrigerating and Air Conditioning Engineers, *ASHRAE/IES Standard 90.1-1989*, 1989, 108 (Table 13-6, System #4).

Table 3. Preliminary summary of the program results.

Construction Budget	A/E Fee	Baseline Energy Cost	Designed Energy Cost	Annual Energy Cost Savings	Percent Savings	Maximum Incentive Fee	First Payment	Anticipated Total Payment
Utah State Hospital Forensic Mental Health Facility - Secure mental health facility. Patient rooms, treatment rooms, food service, recreation, facilities, etc.								
$10,751,900	$591,300	$71,965	$36,020	$35,945	50%	$107,519	$64,511	$107,519
Library for the Division of Services for Blind and Visually Impaired - Library and warehouse								
$11,183,800	$615,100	$88,421	$69,164	$19,257	22%	$111,838	$3,355	$5,592
Utah Department of Transportation Traffic Control Center - Offices and central control center								
$5,166,000	$615,100	$31,052	$15,530	$15,522	50%	$51,660	$30,996	$51,660
Wasatch State Park Golf Course Clubhouse - Clubhouse with food service, retail, golf cart service and storage								
$1,804,000	$113,652	$12,688	$8,288	$4,400	35%	$18,040	$2,7064	$4,510
Val A. Browning Performing Art Center Addition and Remodel - Addition and remodel to performing arts center, music classrooms, practice rooms								
$17,048,800	$1,022,928	$87,872	TBD	TBD	TBD	$170,488	TBD	TBD
Davis Applied Technology Center Medical and Health Services Training Facility - Classrooms for vocational education and training in medical services								
$3,280,000	$196,800	$30,785	$15,428	$15357	50%	$32,800	$19,680	$32,800
Davis County Courts Courthouse - Courthouse								
$8,592,780	$484,633	$65,930	$39,650	$26,280	40%	$85,928	$20,623	$34,371
Utah State University Widtsoe Hall Chemistry Building and Lecture Hall - Chemistry building with research and teaching labs, faculty offices, lecture halls								
$21,177,400	$1,269,000	$349,375	$175,000	$174,375	50%	$211,774	$127,064	$211,774

Total Annual Energy Cost Savings	$291,136
Total Energy Cost Savings Per Square Foot	$0.51
Total Anticipated Incentive Fee	$448,226

Owner Involvement - the Most Important Factor

From our work in this program and other projects, we realize that *an owner (in our case, the state agency that will own the building) who makes energy efficiency a priority and conveys that priority to the architect, is the single most important factor in energy efficient building design.* This holds true with or without a design incentive award.

Most owners are not knowledgeable in energy efficiency, so they rely on the architects and engineers. Most architectural fees reward design teams for high construction costs and replication of past designs. Most often, hiring an energy efficiency advocate to work with the architect to ensure that energy issues are being properly addressed would be beneficial. In this program, the Office of Energy and Resource Planning acted as the energy advocate. However, we only got involved when the design teams asked for our assistance or when the designs were falling short of the 50% target.

In most of the projects, the agency representatives were supportive of the energy incentive program, and therefore the design teams were. In the only project that failed to meet the 25% minimum incentive level (Library), the owners had little interest in energy efficiency. They would not support the positions of engineers from OERP and the Division of Facilities and Construction Management who suggested a different HVAC system than the design team's consultant. The consultant's position was that an evaporative cooling system would put the project over budget and the only way to afford one would be to decrease the size of the building. The owner chose for the larger building. (This is in contrast to all seven other projects that include evaporative cooling without going over budget.)

The question of how to get the owners more interested in energy efficient design is difficult to answer. The problems have been discussed often and are well documented. Our experience is that owners support energy efficiency if: 1) Other features of the building do not have to be sacrificed; 2) Comfort is not sacrificed; 3) Maintenance costs are not increased. Our experience has shown that if energy efficiency is a program goal (rather than an add-on feature) the building will not cost more, the occupants will be more comfortable, and the maintenance costs will not be higher and will sometimes be lower. Therefore, to sell the idea of energy efficiency, we now stress these benefits and offer energy efficiency as an ancillary value.

Design Team Interest - the Next Most Important Factor

Our discussion with the local building design community illuminated both interest and capability of local architects and engineers to design energy efficient buildings. When asked why they were not designing energy efficient buildings, they gave two answers: 1) It is not a priority of clients; 2) The fee structure does not give us the incentive to spend the extra time needed to optimize the design. Our program sent the message that we were clients who were interested enough to increase the design fees by up to 17%. Seven out of eight teams responded.

Bias Toward Success

Because this was an experimental pilot program, we had a strong desire to show initial success for two reasons:

First, we wanted to generate enthusiasm in the design community. Our thought is that if we can influence architects and engineers to work as integrated design teams and make designing energy efficient buildings standard practice, there will be no need for incentive awards.

Second, we felt that initial success would make it easier to continue and expand the program, which we feel is worthwhile.

Our bias toward success was manifested mainly in the creation of the prototype models used to establish the baseline energy cost budget. ASHRAE/IES 90.1 is not comprehensive enough to cover all the situations we encountered, so we had to make things up as we went along. When we were unsure how to go, we chose a way that shaded toward a higher baseline, while remaining fair and objective.

Impact on Design Teams

Upon completion of the designs, the design teams were interviewed. Their responses are summarized below.

What changes if any were made in the design process due to the incentive award? Do you feel the design effort was more integrated than usual?

Most design teams spent more than the usual amount of time thinking bout and discussing energy efficiency. Special meetings were held to address the attainment of energy goals, something that does not usually happen. Decisions were made with participation from all the team members, so that all individuals understood the consequences of decisions on the systems designed by other members of the team.

One architect responded that his engineering consultants were disappointingly reactive instead of proactive as he wanted them to be. His firm then concentrated on managing the solar insolation to take advantage of day lighting and shading.

What if any tools, techniques and analyses were used that are not normally used?

Day lighting ideas were refined with the use of physical models and computer programs. Most teams responded that more attention was given to a wider range of solutions rather than alternative design techniques.

What was the decision making process for including or rejecting energy efficiency features?

The teams mainly used three criteria: life-cycle cost, maintenance costs, and simplicity of operation. The teams had the benefit of experience with the FinAnswer program and therefore knew which features would be successful in a DOE2 model.

Were there features considered that normally would not have been? Were there features considered but not used?

Most of the designs have features that were included because of the incentive program. One engineer reported that he was allowed to design a more expensive system than normal and was allowed more space for mechanical rooms than normal. He explained that budgetary constraints usually affect the less visible aspects of the building, such as the HVAC system. However, given an incentive, the architects found ways to reduce other costs and shift part of the budget to the mechanical system.

One engineer reported that the incentive made him was more aggressive in pushing energy efficient features. He overcame initial objections from the owner; normally he would have acquiesced and designed a typical system. He mentioned that the presence of the incentive program made the owner more receptive to his ideas.

Many features were considered but not used. For instance, lighting controls and daylight harvesting were considered in all spaces but found not cost-effective in some. One idea was to have the space temperature of patient rooms controlled by occupancy sensors, but it was decided that the time it would take to bring the room back to the comfort zone would be too long. This is a case of occupant comfort being more important than energy cost.

What were the biggest challenges?

The architects were generally challenged most by integrating the requirements and desires of the owner with energy efficient design. Many features were dictated by the building program and could not be changed by the designers. Initially, these interests seemed to be in conflict, but the architects were inspired by the incentive fee to come up with solutions that satisfied both requirements.

On the other hand, the engineers were challenged by deciding which features to push for and which to leave out. They expressed a responsibility to design for low life-cycle cost rather than minimum energy usage. The incentive program, however, rewarded for the latter and not the former.

What did you learn from this pilot program?

The design teams learned the value of greater interaction of the members earlier in the design process.

Some individuals expressed surprise that energy efficiency could be designed into buildings without increasing the construction costs.

One architect explained that the experience helped his firm understand how they should be designing buildings. The incentive challenged his firm to think differently and they are now applying that type of thinking to their current projects, which have no incentive award. He feels that they are designing buildings that are not only energy efficient, but more comfortable and user- friendly. He thinks that this type of thinking will define a new trend in American architecture.

How will the incentive award be divided between the architectural and engineering firms?

All the respondents had informal agreements that they would split the incentive award by how much effort was put forth.

Some reported that they were not counting on the final 40% installment payment. They were not confident that the buildings would be operated as intended by the design.

Recommendations

Our pilot program has been successful enough to warrant continuation. We recommend the following changes to improve the program:

Develop Owner Interest

The building owners and users should be educated on the benefits of energy efficient design in terms that matter to them. For instance, the director of Agency 'A' was unconvinced that day lighting should be a feature of his new building. We arranged a visit to an existing, naturally lit building, where Agency 'B' employee satisfaction and productivity are very high and absenteeism is very low. The director of Agency B attributed this to the natural lighting (he had no idea what his utility bills were). After that visit, the director of Agency 'A' made day lighting a priority in the design of his new building.

We had been trying to convince Agency 'C' to consider indirect lighting and lower illumination levels in its new building, but our energy cost saving arguments did not get past the statement from the lighting engineer, "Indirect lighting costs too much." We arranged to have competing indirect lighting fixtures installed in the existing offices of the director and assistant director. Within a few days, dozens of employees requested indirect lighting with lower illumination levels in their offices. The new building was equipped with indirect lighting and came in under budget. (Nobody has noticed that the illumination level is only 30 footcandles instead of the typical 70 footcandles.)

Design Team Selection

A criterion for design team selection should be interest and experience the team has in integrated design and energy efficiency. Select design teams that failed to make diligent effort during previous designs should not be considered.

Project Selection

If a limited number of projects will be entered into the program, try to select projects that are the most simple and straightforward. Select projects that match the cases in ASHRAE/IES 90.1 as closely as possible. Select projects that impose the fewest restrictions (such as site constrictions) on the design teams. Avoid remodels, renovations, and additions if possible.

Development Of The Prototype Model

In the pilot program, we created the prototype models as the design teams were working on their designs. It would be ideal to select the projects and develop the prototype computer models before the design teams are chosen. Then, the design teams would have a solid goal to work toward and could use the prototype model to test ideas in the schematic phase.

Unfortunately, DOE2 is too cumbersome for most design teams to use as a design development tool. Energy-10 is design development software, but does not work well for large buildings. We are looking for a tool that can be used to test energy efficiency design concepts as well as to verify energy cost savings.

Continuous Interaction Between the Modeler and the Design Team

In the pilot program, we anticipated that the Office of Energy and Resource Planning (OERP) would handle the DOE2 modeling chores. However, due to the timing and other projects, OERP was unable to devote enough manpower to the project so an outside modeling agency was hired to create the DOE2 models. There was no interaction between the modeler and the design team. Usually the design teams did no energy modeling and were flying blind. They did what they thought made sense with little or no quantitative analysis of the impacts of their decisions.

In the future, we plan to have the prototype models of the buildings completed before the design teams commence work. This will give the modeler the free time to adjust the model as the design team proposes ideas. With the ideas quantified by computer analysis, the design teams can make informed decisions rather than educated guesses.

Adjust the Incentive Fee Schedule

The pilot program demonstrated that achieving 50% savings over the energy code is quite attainable. In the future, we will raise the level of savings needed to achieve the incentive award.

Financing

We recommend that the owner finance the incentive fee as part of the overall project cost. While we appreciate PacifiCorp's assistance, third party financing is cumbersome and costly. In our case, we recommend that the Utah State Legislature appropriate between one and two percent additional funds to all building construction budgets. One per cent would go toward the incentive award and the remaining would go toward modeling and program administration costs. (In the pilot program, OERP donated modeling and other energy engineering; DFCM administered the program.)

Commissioning

The State has been reluctant to have new buildings commissioned for two reasons: 1) The benefits are not perceived to be worth the cost; 2) There is no commissioning protocol. That is, there is an attitude of, "we have never done it before, so we cannot do it now."

We had expected that by withholding 40% of the incentive fee, that the design teams would find a way to have the buildings commissioned. None did. We will continue trying to have new buildings commissioned to ensure that the designed energy efficiency features have been properly installed and function as intended.

Summary

We have shown that new buildings can be designed to use 50% less energy cost than required by the ASHRAE/IES 90.1 Energy Standard without increasing their construction cost. By offering an incentive award for energy efficient designs, we encouraged design teams to put forth significant additional thought and effort to create energy efficient designs. The pilot program is estimated to save Utah more than $290,000 every year from an initial cost of under $450,000. This equates to annual cost savings of $0.51 per square foot from $0.79 per square foot incentive fee costs.