Creating a Model Energy Efficiency Program in an Era of Limited Financial Resources

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ABSTRACT

Implementing cost-effective energy-efficiency projects can be difficult for over-burdened facilities staff. For example, at Stanford University a small energy management staff has responsibility for over 10 million square feet of building space, including student housing, computer facilities, research laboratories, athletic facilities, and a hospital. To address this concern, the Stanford Facilities Department has developed the Energy Retrofit Program (ERP). The ERP provides monetary incentives to departments for carrying out projects that reduce energy consumption. The main benefit of this approach is that a small energy management staff can implement a large number of projects by enlisting the help of those who are most familiar with each building. Participating departments benefit because they obtain the advantages of high quality, energy-efficient lighting and building controls without using their own budgets. The University benefits because overall energy and maintenance costs are reduced in a consistent, cost-effective manner. During the last four years, Stanford's five million dollar energy-efficiency investment has shown an internal rate of return of over twenty-five percent or approximately seventeen million kilowatt hours per year. This paper describes the pitfalls and benefits of setting up an energy retrofit program and how these lessons can be transferred to diverse facility types.

Introduction

Despite the many claims of falling energy costs due to deregulation of the electricity market, energy-efficiency remains a worthwhile investment for all energy users. First, energy costs are non-discretionary -- the energy bills must be paid. Money used to pay the energy bill cannot therefore be used to further the mission of the business or institution. Second, since less energy consumed also means less energy produced there is a corresponding environmental benefit from reducing energy consumption. Lastly, reducing the amount of energy needed by buildings helps mitigate or delay the need for expensive improvements to the physical plant or other infrastructure.

This paper focuses on developing and implementing an effective program to retrofit existing buildings with more efficient equipment. It is common knowledge that the most cost effective way to make buildings more energy-efficient is to design them that way during the planning process. Unfortunately, much of the existing building stock was built at a time before energy-efficient design was a priority or the now popular energy-efficient technologies became available. Energy retrofits, then, are the only way to improve the efficiency of existing buildings.

The end goal of energy retrofit projects should be not only to improve energy-efficiency but also reduce energy costs and improve occupant comfort. If these criteria are not met then the project should not be considered further. An important side benefit to energy retrofit projects is the reduced maintenance costs that often result after the project is complete.

Background and Setting

Stanford University is a private institution that sits on just over eight thousand acres approximately thirty miles south of San Francisco, California. There are over ten million square feet of building space serving approximately seven thousand undergraduate students and seven thousand graduate students (For more details visit http://www.stanford.edu). The climate is mild; the neighboring town of Palo Alto has an average of 2911 heating degree days and 297 cooling degree days (base 65° F). Electric power is supplied by an on-site forty-nine MW cogeneration facility. Steam and chilled water are also produced at this facility and distributed to campus buildings through extensive piping systems. The average peak electrical load during the summer is close to twenty-four MW. The most energy-intensive buildings are dedicated to medical and chemical/biological research and use in the neighborhood of four-hundred kbtu/sqft/yr. The most intensive building, the Center for Integrated Systems, is used for silicon wafer research and uses seven-hundred kbtu/sqft/yr. Because of the nature of the research and the extensive use of fume hoods, these buildings use one-hundred percent outside air. On the other end of the scale, the libraries are the least energy-intensive of the academic structures at ninety kbtu/sqft/yr.

Energy management at Stanford has taken many forms. In the late seventies and early eighties, a centralized energy management group completed numerous delamping and incandescent to fluorescent lighting conversion projects. Later the emphasis was on high efficiency electric motor, electronic ballasts, occupancy sensors, and variable speed drive retrofits. Despite successes, this centralized group was dispersed largely due to financial pressures on the university. Also during the eighties an industrial grade energy management and control system (EM&CS) was installed. Stanford's EM&CS is a process control system used for monitoring the cogeneration plant, measuring utility service consumption and demand, managing utility demand, central HVAC system control for Stanford's eighty largest buildings, monitoring life-safety systems, and local process control where appropriate. Besides precise building control, most of the energy savings from this system come from the ability to schedule fan, cooling, and heating systems off when they are not needed. This is particularly useful at a university where the building schedules are changed quarterly.

Designing an Energy Retrofit Program

Two critical decisions must be made before an energy retrofit program can proceed. The first is how to fund the program. It is absolutely essential that funding is set aside specifically for retrofit projects. Organizations of all sizes with a single operations budget will find that dollars that could be used for energy projects are soon taken for other operational needs. This is not to imply that the money used to repair leaking roofs or worn out carpet is not a real need. Energy projects require a separate budget and decision criteria because they are an investment with a definable payback as opposed to an on-going maintenance cost. At Stanford, one and one-half percent of our annual utilities budget are set aside each year for retrofit projects. Any grants or utility rebates that are received from previous projects are also put in this pool of funds.

The second critical decision to be made is how to staff the program. There are two ways to administer the dollars set aside for energy retrofit projects. The first is to have a centralized group that identifies and implements the retrofit projects. This approach is often unsuccessful because centralized groups must rely on the good will and cooperation of others (who do not report to the same manager) for help with the implementation of the retrofit projects. Additionally, a centralized group is often a "staff" function distant from the day-to-day operations of those with "line" function responsibilities. A common complaint by building occupants and local maintenance workers is that they feel the retrofit projects are done to them rather than done for them. This is because a centralized group is at a disadvantage when it comes to knowing the special needs of each occupancy group. The second option for administering retrofit dollars is a decentralized or "grass roots" effort where local zone energy representatives identify and implement the energy retrofits while a single manager administers the ERP funding. (The person referred to in this paper as the zone energy representative could take many forms depending on the type of organization. Generally building engineers or someone with working knowledge of lighting and HVAC systems are good candidates.) The zone energy representative knows the concerns of the building occupants, understands the best times to schedule projects to minimize disruptions, knows when future building renovations will take place and can plan accordingly, and is able to explain the importance of the project and gain occupant "buy-in." Finally, the zone energy representative can select energy projects that not only will save the most energy but address maintenance and comfort issues as well. At Stanford, these zones are divided in a way that makes the most sense both geographically and financially. For example, the athletics department has its own staff maintain a large football stadium, a basketball arena, and a pool facility. The athletic staff are familiar with the needs of the coaches, athletes, and administrators who use these spaces. On the other side of campus, the research buildings are maintained by a different group. This group is used to working with the scientists who occupy these buildings and familiar with the specialized infrastructure used to support their work. This strategy is not limited to universities. Any organization, profit or not-for-profit, that pays for utilities can benefit. For example, a retail chain with many large stores might find it appropriate to have a zone energy representative at each location. In some cases it might be better to have one zone energy representative represent several stores in close proximity.

There is a another option that merits discussion. Energy retrofit projects can also be implemented by outside groups. There are any number of shared savings or performance-based contracts that can be arranged. Many large electricity users in California have been approached by energy service performance contractors that package electricity with energy management and lighting services. Although this is often the only option for those with no chance of obtaining internal funding for retrofit projects, this approach has pitfalls. Certainly the economic benefit of any energy savings must be shared. Since so many retrofit technologies have a proven track record there is little risk. Why split the benefits of a sound investment? A high level of sophistication is also needed to understand and monitor most shared savings agreements. Finally, no matter how earnest, an outside contractor chartered to direct the retrofit work can not afford the time to look after the interest of the building occupants or consider long-term maintenance issues.

Establishing the Energy Retrofit Program

Initial effort is required of the ERP manager before the program can begin. The first step is to prepare guidelines for the program. This document is useful in at least two ways. It shows upper management that the ERP funds are dispersed in a rational and logical fashion, and it gives the zone energy representatives some clear rules on how ERP funds can be used. Stanford's ERP guidelines can be found at http://www.stanford.edu/group/EMG.

Role of the ERP Manager: The ERP manager administers the central pool of energy retrofit dollars. The ERP manager also is responsible for providing consistency in the approval and implementation of projects, ensuring an equitable distribution of ERP funds, providing technical guidance, and evaluating new technologies and strategies for future implementation. In addition, the ERP manager continually monitors both the effectiveness of individual projects as well as of the entire program by analyzing the metered consumption and demand before and after each retrofit project.

Next, the ERP manager must determine who the zone energy representatives will be. Naturally, this will vary from organization to organization. The zone energy representative, under the guidance of the ERP manager, is responsible for identifying projects with potential energy savings, calculating the energy savings and project cost estimates, and overseeing project implementation.

Because the facilities are large and diverse at Stanford, there is at least one zone energy representative for every major department. For example, the medical school, housing and dining services, athletics, and academic buildings each have an active representative along with others that help with special building types such as research buildings, libraries, and computer facilities.

The ERP manager must meet with the zone energy representatives, either as a group or individually, to explain how the program works and the timetable for project submission. Since maintenance is almost always under-funded, the zone energy representatives have a strong interest in using ERP funding. Additionally, energy projects tend to be high profile because they improve lighting and building comfort. These projects make a positive change in the buildings the zone energy representatives control. Lastly, the zone energy representatives are often rewarded by their managers for participation in the program.

Managing the Energy Retrofit Program

Table 1, ERP Checklist, outlines the steps in the ERP process. Dates included in this table follow the academic calendar and are shown as an estimate of how long each step might take. A more complete discussion of the ERP checklist follows the table below.

Table 1. ERP Checklist

TASK	*RESPONSIBILITY*	*DATE*
Identify Project with potential energy savings	Zone energy representative	Before September 30
Calculate Energy Savings	Zone energy representative	Before September 30
Estimate Project Cost	Zone energy representative	Before September 30
Send Request for funding to ERP	Zone energy representative	Before September 30
Review Request	ERP Manager	October 15
Send Commitment Letter	ERP Manager	October 15

Obtain Competitive Bid	Zone energy representative/Procurement	Before June 1
Project Construction	Zone energy representative	Before June 1
Project Inspection	Zone energy representative/ERP	Before July 1

All proposed energy retrofit projects are ranked by simple payback. The projects with the best return are funded first until that year's funds are depleted. Projects with greater than five year simple payback are not considered. Some organizations may find that a longer or shorter payback threshold will serve their needs.

Identify Project with Potential Energy Savings: Zone energy representatives look for energy retrofit projects in their buildings as a normal part of their job responsibilities. Maintenance shops and building occupants are consulted for additional project ideas. A good zone energy representative knows that many energy retrofit projects also have significant maintenance savings. A dramatic example is the replacement of an incandescent bulb that lasts 750 hours with a compact fluorescent lamp that lasts 10,000 hours. The labor dollars saved by having an electrician make one trip to replace the compact fluorescent instead of thirteen trips to change the incandescent is much greater than the avoided energy cost. Also, a project that reduces cooling load may also make occupants more comfortable in those "hot spot" areas.

Calculate Energy Savings: Invariably, some zone energy representatives are more skilled in preparing energy reduction estimates than others. For those who require assistance, the ERP manager should maintain a small library of reference materials and catalogs that may be helpful when preparing a funding request. As time permits, the ERP manager may also help the zone energy representative prepare the calculations. Even a math-shy zone energy representative can still be helpful with preparing the assumptions for the savings calculation, generally the most critical part. Also, the ERP manager can prepare aids or example calculations for the zone energy representatives to work from. Useful reference sources include; Advanced Lighting Guidelines (Eley), Illuminating Engineering Society Lighting handbooks, American Society of Heating and Ventilation Engineers handbooks, manufacturers' data, or materials made available from EPA's Green Lights Program.

Estimate Project Cost: Energy representatives usually seek assistance from in-house maintenance shops and outside contractors when preparing cost estimates. Accurate estimates make planning and budgeting easier since project overruns or changes in project scope are not guaranteed funding. Below is a list of the type of documentation that is requested before a funding commitment is made:

- A concise description of the energy system to be retrofitted;
- The location of all the equipment to be retrofitted including supplemental sketches and drawings as necessary;
- The hours of operation of the system(s). For example, within a single building, labs, classrooms, offices, and common areas may all have different hours of operation for lighting and equipment. Similarly, different HVAC fan systems within a building have different schedules;
- A description of all the relevant equipment including all relevant nameplate data, ratings, wattage, voltage, horsepower, and condition and age;
- Metered data or calculations of existing energy use before the project;
- Calculation of the energy use after the project is complete, including calculated reduced peak electrical demand if any;

Review Request: Each project is evaluated for its potential energy savings. Projects with the shortest simple payback are given funding preference. Projects are not considered if they include unproved technologies or will adversely affect building occupants. Additionally, projects that solely involve the replacement of damaged or worn out equipment are best funded through a deferred maintenance program.

Send Commitment Letter: After receiving a complete retrofit package and if the project is determined to be viable, a not-to-exceed reimbursement amount will be committed in writing to the zone energy representative. While this may seem like an extra step, it is helpful to have one document that lists the project specifics, and helps to sort out discrepancies before the project begins.

Project Construction: All phases of project implementation are the responsibility of the zone energy representative. It is also the responsibility of the zone energy representative to make sure that project construction adheres to industry health and safety standards and practices. The zone energy representative should pay particular attention to the rules and regulations regarding confined space access, asbestos issues, proper disposal of PCB ballasts, and the proper disposal of fluorescent (or any other mercury containing) lamps. Generally, most large organizations have policies that address these issues in a consistent manner. If not, then the ERP manager should assist the zone energy representative in making sure that these issues are carefully considered.

Project Inspection. A post construction walk-through is conducted by the zone energy representative and includes the contractor, an ERP representative, and the appropriate in-house maintenance staff. This team reviews project completion for design compliance and completeness prior to closing the project.

Miscellaneous: It is a good business practice to collect paperwork documenting all project expenses including copies of work orders, material and labor invoices, or other requisitions before closing the project. Inevitably, projects have cost overruns or slight changes of scope during construction. Since the goal of the program is to save energy and not simply enforce guidelines, the following statement may be included in the guidelines to cover this situation:

> If the actual project costs are less than the approved amount, all remaining funds shall be returned to the ERP. The ERP is not responsible for funding cost overruns or changes in the scope of the project. However, if additional opportunities for energy savings are identified after a project has been approved, increased funding will be considered if sufficient uncommitted funds are available and the additional work or change in scope follows the normal ERP requirements.

Case Study – Fluorescent Torchiere Project.

In March of 1997, David Frost, zone energy manager for the student housing department, initiated a project to remove five-hundred 300 watt halogen "torchiere" floor lamps from student dormitories. Halogen floor lamps had become popular in the dorms over the years because they are inexpensive (often less than twenty dollars), easy to install, and provided pleasant uplighting that gave the student's dorm rooms character. The student housing department had been watching their electric costs slowly rise as a direct result of the popularity of these halogen lamps. Most students were unaware that halogen lamps are not only very lumen inefficient but also a fire hazard. In fact, the operating temperature of a 300 watt halogen lamp is in excess of 900 degrees Fahrenheit, enough heat to fry an egg in less than three minutes, a dramatic test that has been conducted several times to illustrate the point (Calwell). To make matters worse, the halogen lamps show dismal power factor and harmonic distortion characteristics when dimmed (Page and Simonovitch). The student housing department was understandably concerned about the increasing energy consumption from these lamps as well as the potential fire hazard. Unfortunately, the student housing department was not in a position to fund replacement of these lamps, which left an outright ban of "torchiere" lamps the only recourse. The housing group knew, however, that a ban of the lamps would be difficult to enforce, especially with independent minded students. The best solution, then, was to find a suitable replacement for the halogen lamps that would be both safer and more efficient. Frost worked with Lawrence Berkeley Labs and EMESS Lighting to develop a compact fluorescent torchiere floor lamp that uses sixty-five watts, matches the lumen output of a three-hundred watt halogen, and operates at less than one-hundred degrees Fahrenheit. Frost requested $36,000 of energy retrofit funds to exchange the five-hundred halogen torchiere lamps with the new fluorescent lamps. This project required a tremendous amount of coordination by the student housing department. First, dormitory rooms were surveyed for the number and location of the existing halogen floor lamps. Next, the students and dorm staff had to be sold on the benefits of the new lamps and convinced of the importance of the project. Although the ERP provided funding and technical and logistical advice, the project was a success because the housing group had a real interest in the outcome. The torchiere project received well-deserved attention, including coverage by all of the San Francisco television stations and the Wall Street Journal. On the financial side, this project had a two-year payback, reduces energy consumption by over 165,000 kWh per year and reduces demand by over one-hundred seventy kW.

This project would not have been completed without the ERP. The campus housing group cannot free money for even the most attractive energy retrofit projects despite their enthusiasm towards energy-efficiency. On the other hand, because the housing group already had staff that was familiar with the buildings, they could handle effectively the logistics of surveying rooms for the old lamps, distribute the new lamps, and ensure that the goals and benefits of the project were well communicated. In short, the campus housing group could integrate this project into their normal operations. An outside group, lacking this "in-house" advantage, would have needed significantly more time and resources to implement this project.

Results and Conclusions

There are two ways to measure the results of this program. The first is a look at the quantitative results – how much energy has been saved for the number of dollars spent. Through the end of Stanford's last fiscal year (August 97) the ERP has funded 178 projects with an estimated savings of over seventeen million kWh or 1.3 million dollars. There has been quite a range in the size and scope of ERP projects. The largest project was funded for over $500,000 and the smallest for just under $3,000 with the average project in the $50,000 to $75,000 dollar range. This year another $750,000 in projects have been identified at an average payback of 3.6 years.

An effort has been made to compare the predicted savings with the actual changes in the metered consumption. A full discussion of this effort is beyond the scope of this paper, but a few highlights are worth mentioning. In the buildings where we have the ability to measure and trend electric demand, we have examined the changes that resulted from a full building lighting retrofit. In the Terman Engineering Center, the actual demand reduction for installing T8 lamps and electronic ballasts, occupancy sensors, compact fluorescent lamps, and LED style exit signs was slightly higher than the pre-construction estimates. After the retrofit, the measured savings were 21% of the annual kWh consumption and 22% of the kW demand. These measurements were taken with a watt transducer connected to the central campus EM&CS system.

Unfortunately, Stanford does not have the resources to compare all of the actual energy reductions with the estimates, a problem that many organizations face. With limited resources, is it better to study the results of completed projects, or to put that same effort into identifying new energy retrofit projects? Even with the time to review completed projects, the benefits from the retrofit projects are sometimes difficult to measure at the building meter. It could be that the retrofit project is small compared with the total building consumption or background increases in energy consumption due to changes in the building operation conceal the energy savings.

More difficult to quantify but just as important are the non-economic benefits of the ERP. By using a decentralized approach, more people are attuned to the cost of energy and the benefits of reducing energy use. Not only does this equate to more and better quality retrofit projects, but this awareness also translates to energy reductions that cannot be economically addressed through technical means, such as turning off copy machines, computer terminals, and lights in areas without occupancy sensors.

Finally, some additional lessons:

- Product warranties and the ability to honor warranties should be given a high priority when selecting products;
- Every effort should be made to standardize lamps, ballasts and other parts so the inventory of replacement parts can be minimized;
- Where possible, retrofits should be made as permanent as possible. For example, new fixtures should be installed instead of using screw-in compact fluorescent lamps which can be replaced with incandescent bulbs;
- Contractors should be evaluated for reliability, price, and responsiveness;
- The in-house maintenance shop responsible for the on-going maintenance must be trained on how to maintain the new equipment;
- Building occupants must be made to understand why the project is necessary and how the project benefits them. This is especially true with more active energy reducing products such as occupancy sensors or thermostats. If the building occupants understand how the product works, they are less likely to try to defeat it;
- In-house maintenance shops should be encouraged to bid on the retrofit projects against outside contractors. On the plus side, using in-house labor will increase project buy in and the staff will be on site to troubleshoot problems. Exit sign and occupancy sensor retrofits can be done to keep the electrical staff busy during slow periods. In this way, the real cost of the project to the organization is reduced. On the down side, the project can take longer, thus delaying the energy reduction. Another caution is that outside contractors are not as likely to get pulled away by an emergency or be subject to slowdowns due to illness or injury;
- Implementing several projects at one time in a single building can reduce the disruption to building occupants, make projects easier to manage, and simplify the tracking of energy savings;

- Even at a facility that has had an active energy management program for a long time, there are many excellent energy retrofit investment opportunities;
- Excessive requests made of the zone energy representatives slows down the retrofit implementation process and drains enthusiasm. Limit program paperwork requirements to the bare minimum. Information that is useful, but not necessary, can be collected directly by the ERP manager;

Despite a strong economy, financial pressures continue to increase on all organizations to do more with less. Enlisting the aid of those who work most closely with the building occupants is an effective way to identify and implement energy retrofit projects. A central pool of funds guarantees funding of the energy project with the best return. Together the best use of limited financial resources is ensured.

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