TOWARDS AN ENERGY EFFICIENT FUTURE: THE ILLINOIS SMART ENERGY DESIGN ASSISTANCE PROGRAM

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1. INTRODUCTION

Buildings and building related activities represent one of the largest energy consuming sectors in the United States. In Illinois, from 1950 to 1990 a population increase of approximately 2.7 million translated into dramatic natural resource consumption increases. For example, Illinois residents currently require almost 30 million gallons of petroleum per day. According to the U.S. Department of Energy, annual energy expenditures in the State have now reached over $34 billion with commercial buildings consuming over $5.6 billion alone. This represents an increase of over $14 billion since 1980. Overall energy consumption in Illinois amounts to 3.96 quadrillion BTUs, nearly two-thirds of which can be attributed to buildings and building related consumers.

In Illinois the building and construction industry is also an important part of the economy, employing over 250,000 persons at an annual payroll that exceeds $11.2 billion dollars. Clearly, energy efficient facility initiatives that have even modest success in transforming Illinois markets by reducing consumption, increasing efficiencies, and reducing waste can have large impacts on the State's economy.

This paper presents the process and results of a smart energy design assistance initiative begun at the School of Architecture's Building Research Council at the University of Illinois. Begun to help designers and engineers implement renewable technologies and realize more efficient structures and projects, the program has also been successful in helping Illinois businesses remain competitive in the global marketplace by helping them reduce operational (energy) expenditures. Program results have shown the typical building can reduce its energy consumption by 30–40 percent through readily available "state of the shelf" efficiency measures.

2. THE ILLINOIS SMART ENERGY DESIGN ASSISTANCE CENTER

The Smart Energy Design Assistance Center's (SEDAC) mission is to encourage Illinois building owners, designers, and users to incorporate renewable energy systems and energy efficiency practices into the built environment for businesses. SEDAC accomplishes this by providing information and design assistance in the practices and implementation of components of energy efficient design, specification, construction, and education to business owners and practitioners. SEDAC also provides support for the Illinois Energy Code, assists with the financial strategies needed for project implementation, and provides assistance for more broadly defined sustainable design initiatives within the State of Illinois.

The initial concept of the SEDAC was tested under a pilot project in late 2004. This project was part of the Illinois' Small Business Smart Energy Program. This program is part of the State's Opportunity Returns initiative directed by the Illinois Department of Community and Economic Opportunity (DCEO). The smart energy program is designed to provide assistance to businesses for identifying opportunities to save energy and money, and reducing overhead and operational costs. It also supports resource efficiencies in building design, materials selection, and construction practices as they relate to energy. This program is administered by the University of Illinois at Urbana-Champaign (UIUC) at the School of Architecture's Building Research Council (BRC).

In the pilot program, the project team performed design assistance energy audits, feasibility studies, and follow-up for 20 small businesses in Illinois. The goal was to help implement energy efficient building design or redesign strategies. The pilot attempted an even dis-

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tribution of projects across the state—two per economic development region. The work included actual design assistance analysis as well as the presentation of the financial benefits of the recommended improvements to the client small businesses. The SEDAC was developed out of the pilot to implement the Small Business Smart Energy Program for a larger small business customer base and a greater range of clients.

In the future, as the program grows and funding sources diversify, SEDAC information and services will be available to: nonprofit customers, institutional building owners (government agencies, schools), historic preservation entities, communities, and larger-scaled businesses. Other customers targeted include national agencies and entities interested in Smart Energy implementation and information.

The SEDAC also includes a strong training and educational component, aimed at professional development, and many of the courses offer continuing education units. Some training is project-oriented and designed specifically to help individuals working to gain requisite knowledge in energy efficient design and applicable new regulations and codes with an emphasis on recent codes adopted by the State of Illinois. The SEDAC educational curriculum is coordinated within the University through the Office of Continuing Education and will be targeted toward professionals (e.g., architects, engineers), UIUC students (in Architecture, Planning, and Engineering), facility contractors, and facility managers. These educational programs are focused on sustainable design and will eventually provide University certification in sustainable design.

3. DESIGN ASSISTANCE ACTIVITIES

Operation of the Smart Energy Design Assistance Center includes four tiers of service to clients. These are initial consultation (Level 1), energy audits (Level 2), design assistance (Level 3), and project follow up (Level 4). Overall, program intervention will be aimed at familiarizing project engineers and others on innovative, energy efficient design approaches.

The project team understands business realities, and when performing analyses for energy efficiency and renewable energy, we treat these as a business decision. Therefore, we present financial analyses with tables that contain the monthly cash flows, internal rates of return, and net present values, utilizing a standard set of economic assumptions and investment criteria. SEDAC also periodically reviews the assumptions used for discount and loan interest rates and updates as necessary for market alignment. If a client indicates a preference, then the client preferences are used in the analyses.

Level 1: Initial Consultation

Level 1 assistance includes a variety of interactions with design professionals, building owners, and other stakeholders. These initial consultations include one-on-one meetings, presentations, telephone calls, and other correspondence; the purpose will be to inform individuals and organizations about the program opportunities, answer program questions, offer technical assistance with respect to energy efficiency and renewable energy, and assess the potential value of providing additional program services for that client.

Level 2: Energy Audits

The SEDAC performs preliminary energy audits on businesses that request that service. The audits include a review of any existing plans for scheduled construction or renovation, or, in the case of existing facilities, a site visit and consultation is conducted. When the building is still in the pre-construction phase, SEDAC reviews the engineering plans and provides recommended approaches to enhance energy efficiency. The result will be suggestions for project engineers, architects, and other stakeholders for how to develop and incorporate innovative and efficient design techniques and elements.

For each project, the SEDAC analyzes the building usage requirements and general building characteristics, and provides a ranked set of energy cost reduction measures (ECRMs). Once the energy audit is completed and the potential for energy savings has been determined, the SEDAC evaluates the benefit of a complete design assistance process and provides recommendations to the SBSE program participant.

The SEDAC performs a four-step energy audit. Step 1 of the site visit includes surveys of the building envelope (non-energized systems) and energized systems (all energy using equipment). The next step is a review of the energy users in the building and how they impact consumption (human system).

The third step is a review of the energy bills and rate structure. The process is to assemble at least one

year of consumption data for each type of energy used. Then an energy usage spreadsheet and plots of the data is created. Also the energy usage is related to weather and product output. The goal is to investigate suspicious trends such as summer natural gas usage, winter electrical usage, or usage spikes. Finally, we determine overall $/kWh cost, overall $/therm cost, and benchmark (dollars/sf and Btu/sf) as necessary. The benchmarks are compared with ENERGY STAR® Target Finder or USDOE Commercial Building Energy Consumption data (CBECs).

The last step is to identify energy efficiency opportunities. For an audit, we have a standard set of opportunities that we review, plus any unique items like process loads in the client's building. For instance, we find most grocery and convenience stores benefit from refrigeration efficiency options.

Level 3: Design Assistance

This level of assistance involves a more in-depth building analysis than the energy audit and includes four steps:

1. Energy simulation modeling, differential energy calculations, or comparable spreadsheet calculations of the facility.
2. Evaluation of individual and resultant energy cost reduction measures (ECRMs).
3. A life cycle cost analysis that identifies specific energy cost reduction measures and their potential savings and investment parameters.
4. A final feasibility report.

The SEDAC staff or contract Design Assistance Experts are engineers, architects, and design experts skilled in designing and implementing energy efficient construction techniques. These experts can review bid documents, complete and/or review life cycle cost analyses, and provide assistance with a variety of design and other project documents. The SEDAC also provides training to other partners, including architects, engineers, and contractors, such as HVAC contractors and geothermal well drillers. When geoexchange systems are specified, the SEDAC enlists the services of nationally recognized geoexchange design experts, engineers, and architects capable of incorporating the technology into a variety of heating and cooling applications. The SEDAC staff and contractors only assist the local engineer and project staff on select aspects of system design that affect overall energy efficiency and performance and do not actually design the system or replace the local engineer. SBSE applicants will have complete control over personnel decisions that affect a particular project.

Level 4: Follow Up

SEDAC provides clients with Level 4 services based on the SBSE, their needs, or when the SBSE participant meets obstacles to the implementation of the recommended energy efficient technologies. This is an important element of the program since the ultimate goal is to implement energy efficiency improvements in order to realize the potential savings. Both Level 2 and Level 3 program participants may also receive Level 4 services. These services include guidance on: financial options, bids, specifications, contractor relationships, and other services as required for implementation of energy efficiency improvements.

4. DESIGN ASSISTANCE RESULTS

After looking at several hundred commercial buildings, we have noticed some consistency in the energy costs savings opportunities we recommend. The general categories are lighting, HVAC controls, energy conversion system efficiency, insulation levels, windows, air sealing, heat recovery, and control of ventilation systems.

- Lighting options in existing buildings consist mainly of conversion of T-12 fluorescent and high pressure sodium lighting to T-8 fluorescent lighting with electronic ballasts and automatic controls. We find that Super T-8 systems can produce energy savings as high as nearly 40 percent. Another abundant lighting option is replacing incandescent lamps with compact fluorescent lamps. New building designs benefit from more efficient fixtures, better layouts, and motion detectors.
- Many buildings either do not have programmable thermostats or they are installed, but not used effectively. Owners are taught how to program and use them.
- Many older buildings lack sufficient insulation levels by today's standards and suffer from improper placement of insulation and lack of vapor barriers. These buildings also tend to have high

levels of infiltration and benefit from air sealing. Also, new designs tend to be minimum code and would benefit from higher insulation levels.

- Both new designs and older buildings benefit from high efficiency boilers and furnaces. We recommend sealed combustion units which utilize outside air for combustion. The same goes for gas-fired unit heaters. In addition, radiant heating is an excellent retrofit for areas of high air turnover and open doors such as auto repair facilities. If replacing air-conditioning, we recommend selecting a new unit with EER of 13 or greater.
- For replacing windows in older buildings, we recommend selection of Low-E types, with U-values of 0.4 or less. We also recommend low-E types for new buildings.
- Most older and new buildings do not have heat recovery. We recommend the consideration of enthalpy wheel type ventilation heat recovery systems where exhaust flows are above 4,000 cubic feet per minute. Also most buildings lack control of the ventilation system. In retail spaces and other spaces with highly varying occupancies we recommend the application of demand control ventilation. For other types of building we recommend the ability to schedule ventilation rates. Only ventilate when the building is occupied or in proportion to the number of occupants.

5. PROGRAM OUTREACH

The SEDAC conducts a marketing communication and public awareness campaign to general members of the public, industry professionals, and mass media outlets and trade press for article placements. This is composed of press releases, newsletters, case studies, niche market materials, a Web site and informational talks and briefings.

The SEDAC issues press releases to local media directly, through the University of Illinois, and through the Illinois Department of Commerce and Economic Opportunity. Project staff will pitch story ideas to small business-related magazines and newspapers, association newsletters, and regional publications that report on local economic growth and business opportunities. Project accomplishments are announced to attract publicity and generate additional program interest.

The SEDAC publishes a monthly newsletter highlighting the program's activities, announcing schedules and calendars, and describing successes in the program. Articles focus on outreach to the niche markets targeted by the SEDAC along with general interest energy related topics.

The SEDAC also develops case studies and technical notes to publicize program successes and provide technical information to the design community. These are posted on the SEDAC Web site and are included as available information for dissemination through the SEDAC.

The SEDAC is also developing marketing and educational materials for client awareness and practitioner knowledge development. The niche market materials address energy efficiency for special sectors of the business economy where SEDAC feels market opportunity exists and assistance can be effective. These will be aimed at the niche markets such as hotels, restaurants, convenience stores, and retail facilities that have been targeted for enhanced marketing and outreach.

The SEDAC Information Center accommodates requests for further information from the public and disseminates energy publications authored by the EPA and DOE as appropriate and makes them available on the SEDAC Web site. Audiences include Illinois businesses, architects, engineers, contractors, planners, students of architecture, and other interested members of the public. The team also makes maximum use of the Web site to provide a medium for electronic information dissemination—newsletters, updated calendars and training schedules, technotes, and case studies, as well as other relevant electronic information. The SEDAC Web site acts as an information clearinghouse for energy related news and guidance. The SEDAC also maintains a toll-free line and e-mail response capability through the Web site interface. The Web site includes a financial analysis tool that provides clients with the ability to calculate cash flow analyses, internal rate of return (IRR) and the net present value (NPV) of energy efficiency projects (http://www.ao.uiuc.edu/energy/). The SEDAC also presents the availability and results of working with the program at numerous venues throughout the State of Illinois and throughout the year.

6. PROGRAM RESULTS

As of June 30, 2007, 877 Illinois businesses have received information and support from the Small Business Smart Energy (SBSE) Program. These Illinois businesses have more than 17,500 employees and comprise over 10 million square feet, representing a geographical cross section of the state. Of these businesses, 138 have received Level 2 or Level 3 reports with quantitative energy saving project recommendations. Our analysis suggests that, with a one-time investment of $23.3 million, these businesses could accrue annual energy cost savings of over $5.7 million. For a project life of 20 years, this translates into a 28.5 percent rate of return on investments made. At a 10 percent discount rate, the energy cost savings represent almost $27.5 million in net present value terms. From a business perspective, the recommended projects yield $170,138 in positive monthly cash flow ($478,199 in monthly savings minus $308,061 in loan payments if financed for 10 years at 10 percent).

The savings identified in these projects can have a considerable impact on the State of Illinois' economy. If implemented, the recommended energy cost reduction measures (ECRMs) could help the participating Illinois small business owners reduce their monthly operational expenditures by $478,199. The $5.7 million in projected energy cost savings (estimated with energy costs at the time each individual project was conducted) may then be used to help these small businesses expand operations and create job opportunities—improving their ability to compete in the global marketplace.

SEDAC has found that energy savings range from a low of about 12 percent to a high of 85 percent depending on the type of building and whether or not it is a new design. The average savings of the building set that we have analyzed is about 39% energy savings. Energy cost savings range from 10 percent to 83 percent with an average of 40 percent. It should be noted that the bounding projects were not the same bounding projects for the energy savings. Monetary savings varied considerably, either higher or lower than the energy savings. Monetary savings depended on the type of energy saved and whether or not electrical demand savings were part of the mix.

The smart energy program cost to do the studies and analyses and recommend savings of a million Btus (MBtu) is $16. This is compared to 2006 annualized energy prices for commercial customers in Illinois of $10.96 (ranging from $8.91 to $13.41) for natural gas to $27.40 for electricity (Source: U.S. Department of Energy, Energy Information Administration, 2007.) In 2007, the electrical cost for commercial customers is expected to be about 10 percent higher than in 2006 due to electrical deregulation coming into effect. Based on the energy savings potential identified by SEDAC, the client investment to save a million Btus is estimated at about $68. This equates to about $2.24 per square foot. This is a weighted average between upgrading old buildings and the differential cost to upgrade new buildings. The SBSE Program continues to gain momentum, and we expect that program cost metrics will continue to improve as recommended ECRMs are implemented.

Based on the clients who have identified ECRMs that will be implemented and those where the decision not to implement has been made, the SBSE Program has cost approximately 12 cents per therm saved, 1 cent per kilowatt hour (kWh) saved, approximately $28 per kW of implemented demand reduction, or approximately 5 cents per dollar saved by the program. (See Table 1 for more details.) It should be noted that the total cost of design assistance is used to value savings of each energy commodity individually; yet actually, all of the energy and demand savings will be realized for the total cost of design assistance (and the recommended ECRMs).

TABLE 1. SBSE Program Return on Investment

SBSE Program has saved...				
1 therm per $0.12	1 kWh per $0.01	1 MBtu per $0.82	1 kW per $28.49	$1 per $0.05

Specifically, $1,907,000 invested in implemented energy savings divided by:

- 20 years × 390,695 therms = $0.12 spent per implemented life-cycle therm saved;
- 20 years × 6,372,937 kWh = $0.01 spent per implemented life-cycle kWh saved;
- 20 years × 57,850 MBtu = $0.81 spent per implemented life-cycle MBtu saved;
- 20 years × 1,674kW = $28.49 spent per implemented life-cycle kW saved; and,
- 20 years × $1,012,635= $0.05 spent per dollar saved.

Since it generally takes substantially more time for businesses to implement the recommended ECRMs than it takes for SEDAC to provide design assistance recommendations to additional businesses, there is a lag time for realized savings. This lag time makes it challenging to accurately assess the present value of the program investments and savings. The ultimate goal of the SBSE Program is to make energy efficiency the norm in small business operations in Illinois. A dramatic market transformation and paradigm shift has begun, and performance indicators suggest the program is steadily producing positive results. Of the 69 businesses that have reported on implementation, 80 percent (55 businesses) have implemented or started to implement ECRMs. For those 55 businesses reporting implementation, 47 percent of the potential MBtu savings were implemented and 43 percent of the potential cost savings were obtained. The difference in the energy and cost savings results from the rate structures and the type of energy saved. Also, energy cost savings occur at the marginal rate, which is generally the lowest paid.

The businesses that have received design assistance through the SBSE Program can potentially save 341,040 million Btus of energy annually. In addition to saving $5.7 million per year, the proposed energy savings of 2,267,405 therms and 35,904,900 kilowatt hours could also provide important environmental and public health benefits, including the prevention or avoidance of the following estimated[1] emissions:

- 53,918 tons of carbon dioxide (CO_2)
- 181 tons of sulfur dioxide (SO_2)
- 116 tons of nitrogen oxides (NO_x)
- 8.6 tons of carbon monoxide (CO)
- 2.78 tons of particulate matter (PM_{10})
- 1.5 tons of volatile organic compounds (VOCs)
- 0.28 pounds of mercury (Hg)

IMPLEMENTATION

The goal of the program is implementation and, although we aim for a 100 percent implementation rate, research of and experience with similar programs has shown that the ECRM implementation rate is often between 50 and 75 percent. Of the 68 businesses who have reported on implementation, 80 percent have implemented all or some of the recommendations. This program is diligently working to improve the implementation rate. As the program has evolved and matured, it is now managed toward higher implementation rates by selecting more committed clients and ECRMs that have a higher probability of execution.

Fifty-five program participants have implemented or have started implementing some or all recommended ECRMs. At this time, the remaining participants are planning to implement, still considering whether to implement, or have decided not to implement recommended ECRMs.

In short, 138 Illinois businesses have received Level 2 or 3 reports and consultations providing detailed energy cost reduction measures:

- 55 Illinois businesses have implemented or started to implement some or all recommended ECRMs.
- 23 Illinois businesses are planning to implement some or all recommended ECRMs.
- 46 Illinois businesses are still reviewing whether to implement all or some recommended ECRMs.
- 14 Illinois businesses have decided not to implement recommended ECRMs.

It should be noted that over time the amount of businesses who decide not to implement has remained rather static and is not growing with the number of clients served. Of the 14 businesses who are not implementing, eight are from the pilot program, before client screening was more thorough. Also, two of the new building projects have been cancelled, two of the clients are out of business, and three indicated they needed grants to proceed. One client, a bank, did not implement on the project analyzed, but fully implemented on the next branch bank they built.

As mentioned above, businesses that have implemented or started to implement the recommendations have garnered only about 40 percent of the potential savings. A review of the types of project implemented projects indicates that they lean towards the no-cost and lower-cost options. Most businesses have indicated a desire for monetary assistance, either in the form of grants or low cost loans to help them with implementation. The lack of available capital is hindering businesses from obtaining greater energy savings through energy saving investments even though the return on that investment surpasses their business hurdle rate.

CONCLUSIONS

According to the U.S. Department of Energy, annual energy expenditures in the State of Illinois have now reached over $34 billion dollars. The State's commercial building sector is responsible for a large percentage of this expense. Among the policy initiatives and strategies aimed at decreasing this burden on Illinois small businesses is the Smart Energy Design Assistance Center, a program designed to enhance Illinois small business energy efficiency, thereby reducing their bottom line costs and improving their economic competitiveness and viability. The program provides a centralized mechanism for Illinois businesses to obtain energy conservation information, energy audits, detailed energy simulations, and direct implementation assistance on energy conserving design alternatives and their potential for financial return. The unique program has been successful at reducing the overall energy consumed in the state by saving over 341,000 million Btus of annual energy and over $5.7 million per year for the businesses that have taken advantage of the services. These energy reductions translate directly to additional social and environmental benefits including carbon dioxide, sulfur dioxide, nitrogen oxides, and carbon monoxide reductions.

While the immediate and short-term economic and environmental benefits of the program are clear, the long-term educational benefits of SEDAC also are important to note—their inclusion makes the Center a unique and nationally significant entity.

Education and training is a key component of SEDAC. Professional development courses, direct training opportunities for students and professionals, university classes, and the direct training of students through their involvement with the program are critical in teaching and spreading information on energy conserving alternatives.

The word of mouth success of SEDAC has shown that businesses in Illinois are interested in energy savings and improving their bottom lines through energy conservation. Their willingness and interest in participating and investing in the recommended technologies have improved progressively over the term of the program. A general lack of available capital, however, might be hindering an even greater success in implementation for small businesses. Small businesses, by definition, typically lack the capital needed to make needed improvements. The current set of incentives, such as the business tax deductions or the tax credits for renewables and other technologies in the Energy Policy Act of 2005 might not be sufficient to spur energy efficiency investments on a large scale. It appears that the impediments to saving energy might be too large and the monetary rewards too small for the small-scale business owner.

The impediments to expanding and sustaining single focused energy programs such as SEDAC are numerous. Many business owners lack a fundamental understanding of their enterprise's energy consumption and may not understand the need to improve it—or its potential for return. This might keep many business owners from seeking assistance in the first place. Since they are not well versed in the process of saving energy, some have expectations that do not fit with reality. Many are seeking a magic bullet to lower their costs and are disappointed to find that energy saving strategies are a combination of many small things that add up to a larger whole. Small businesses are also apt to occupy small buildings, limiting the potential savings opportunities simply by the small scale of the implementation.

A goal of diversification and expansion of SEDAC to include other potential building and user types would improve the overall viability and success of the program. The potential for energy savings in government, non-profit, schools, and housing facilities is great and yet missed by SEDAC in its current, single focused configuration.

The Illinois Smart Energy program is unique in the nation. It is a relatively new program (2005) that has taken time to establish its presence and inform small businesses of the services available to them. It remains, however, that businesses that have implemented energy costs reduction measures recommended in SEDAC reports are obtaining about 40 percent of the recommended savings—a vast improvement over pre-SEDAC usages.

NOTE

1. Conversion factors used to estimate emissions reductions were taken from the report "Emissions Factors and Energy Process for the Cleaner and Greener Environmental Program," April 2004, by Leonardo Academy, Inc.