Creating a Synergistic Energy Saving Environment Through a Demand Side Management Program

Prasad Vaidya, The Weidt Group
David Eijadi, The Weidt Group
Tom McDougall, The Weidt Group
Jay Johnson, The Weidt Group

ABSTRACT

In 1993 an energy design assistance service (Energy Assets) was introduced in Minnesota that engineered rapid social changes towards energy efficiency through integrated building design. The program achieves success in altering traditional design team synergies by providing new information to designers and owners early in the design through a credible process and by following up with an implementation-verification procedure. For each building, approximately 70 alternative strategies are evaluated without compromising the design aesthetics.

By early 2001, the program had addressed over 31 million square feet, an average energy savings of 28% compared to the local energy code, and with an estimated annual savings of $12.4 million in operating energy costs and reduction of 46 peak Megawatts. The Energy Assets process is now standard practice for many design firms, with a steady acceleration in the number of buildings served by the program. Through repeated interaction with the program, the design and client communities have also improved their baseline designs.

In this paper:

- We summarize the extent of market penetration by Energy Assets and the diversity of savings achieved by the program.
- We argue that the diversity of savings has been achieved due to the whole building analysis for energy conservation.
- We demonstrate the changes effected by Energy Assets in the design community by looking at trends in initial design savings, final savings, and incremental costs of selected strategy bundles, across the first eight years and 115 completed building projects.

Introduction

To create a stronger economy and a cleaner environment for Minnesota, Energy Assets, a utility-sponsored energy design assistance program was introduced to the community in 1993. Initially, 3 pilot projects were completed at the University of Minnesota as a research project called Technology Transfer to Architects and Professionals funded by the Minnesota State Department of Public Services. At this transition, the program was envisaged as a demand savings program where the utility would provide construction incentives to new building owners for reducing electric peak compared to the local energy code base level. Specific goals for achieving peak kilo-watt (kW) savings are set up each year, and the overall program cost at $360 per kW saved has been maintained at about half the cost per kW of building new capacity through additional power plants[1]. In addition to the target to achieve demand electric savings, the building projects that participated in the program achieved comparable savings in consumption for all energy end-uses and fuels. Energy Assets has achieved diverse savings that are not considered typical to demand savings programs that use component rebates.

The diversity of savings and the success of the program can be traced to an open-ended whole building consulting approach, where conservation strategies that impact varied building end-uses are analyzed, often with significant input and suggestions from the design team itself. The program encourages whole building integrated design by providing information to owners and designers early in the design process. This information is primarily in the form of results from DOE2 computer simulations of energy savings strategies. In addition, the designers, owners and contractors are provided information of how strategies need to be implemented in the design. Subsequent to the designers' and owners' decision to implement a set of strategies, they are guided through the documentation process to ensure that the selected strategies are designed into the building, and after initial occupancy, the verification portion of the program provides information about how far the strategies have been implemented and how well they perform. For each project, the process evaluates approximately seventy alternative strategies to affect all energy end-uses and fuels, without compromising the original design aesthetics. The owners and designers decide to implement an average of ten strategies in a building. The utility funds the consultant-based analysis and verification processes, compensates the architectural and engineering team for their participation, and provides incentive money for implementing cost-effective strategies. The incentives are based on the peak kW saved compared to a Minnesota Energy Code level design.

The program has achieved significant market penetration for its targeted building size, so much so that the Energy Assets process is now standard practice for many design firms in the area, and the number of buildings that are included in the program has been increasing steadily every year. Through continued interaction with the program, design firms that have participated repeatedly have learned to incorporate cost-effective conservation strategies as a matter of course, albeit with the expectation of financial incentives for their clients.

Summary of the Program

From 1993 to 2001, the Energy Assets program completed energy design assistance to 115 buildings that add up to 31.7 million SF of new commercial construction. As the program attained maturity, from 1997 –2000 it addressed more than 50% of the square footage of its target market. Peak electric savings average 28%, totaling 46.3 MW. Average CO_2 reduction is 28%, more than 135,000 tons per year. Energy cost saving for building owners adds up to $12.4 million per year. All savings are based on comparison to the

[1] Northern States Power (Lawless 1998) estimated the average baseline cost for new power plants to be at $615 per kW (this does not include the cost of fuel and operation).

Minnesota Energy Code[2]. The program costs are recorded at $360 per kW saved and 0.089 per kWH saved (Gauthier 2002).

Table 1. Savings Summary

Area SF	Code Level Peak kW	Peak kW Saved	% Peak kW Saved	Code Level Annual Energy $	Annual Energy $ Saved	% Annual Energy $ Saved	Code Level Electric MWh	Electric MWh Saved	% Electric MWh Saved	Code Level Gas Mbtu	Gas Mbtu Saved	% Gas Mbtu Saved
31,677,952	166,109	46,337	28%	41,905,451	12,417,589	30%	573,232	173,505	30%	1,857,339	414,365	22%

Table 1 shows that both average peak kW savings and overall energy savings (electric and gas use), range around 30%, and gas savings are a bit less at 22%. While the program has a peak electric demand reduction goal, there are corresponding savings in energy usage, both gas and electric. The total incremental first cost to the building owners to implement these change is reported through the program to be at $7.5 million (an aggregated payback of 1.15 years)[3]. This is further reduced by the construction incentive paid out by the utility. Field verification reveals that designers and owners have implemented strategies that would add up to save an average of 94% of the savings predicted for the selected bundle.

A Case for Whole Building Analysis

Energy Assets is a demand savings program that aims to reduce the peak electric kW. Design teams and owners are paid incentive based on the peak kW saved for implementing bundles of strategies. These savings are achieved through an energy design assistance process built around DOE2 simulations. The design assistance consulting is open-ended, in that the energy savings strategies are not restricted simply to installation of specific equipment. Design strategies such as window sizes, glass types, sunshading, specific equipment strategies such as variable speed drives, and motor, chiller and heating efficiency improvements, and control strategies such as daylight sensors, occupancy sensors, CO2 sensors are typical. In addition to these, designers often suggest additional strategies like ice storage or displacement ventilation that may be specific to the project or their design practice. All these strategies affect different building energy end-uses and fuels. While most strategy types result in some peak electric savings, a few (such as heating efficiency improvements, sensible heat recovery, or nighttime lighting controls) do not. It is typical that during the analysis for each building multiple strategies will be run (e.g. 6-8 glass types) for a given strategy type, to allow the selection of the most suitable strategy (e.g. most suitable glass type in terms of aesthetics, energy savings and first cost). After reviewing the savings

[2] The Minnesota Energy Code is similar to ASHRAE 90.1 1989, but slightly stricter with lower lighting power densities allowed. The Energy Assets program compares the performance of the building design with a version of the design that is back-engineered to this code. The code level version of the designs provide a consistent benchmark and prevents gaming of the process by design firms.

[3] Out of the 115 building projects included in the analysis for this paper, data for incremental costs was available on 93 building projects. In some cases, by going through the design assistance process, designers were able to eliminate strategies that had been included in their initial proposed design but provided only marginal energy savings (like high levels of insulation), thus redirecting the construction costs towards strategies that provided more savings and enhanced the quality of the spaces (like lighting design); this approach has kept the incremental costs down for such projects, and sometimes has resulted in decreased construction costs; such projects have contributed to keep the aggregated incremental cost and payback low for the program.

for each individual strategy and its related incremental first cost, the designers and owners compile suitable strategies in to alternative bundles. These bundles are simulated to account for the interactions between the individual strategies. After reviewing the savings for the alternative bundles, designers and owners select one bundle of strategies for implementation.

For the analysis in Figures 1-10 the strategies that represent the median savings, for a strategy type for each project are selected[4]. For each such selected strategy, percent savings for peak electric kW are plotted on the x-axis and other metrics in terms of percent savings (annual energy cost (annual $), annual operating energy at site (annual btu), annual electric consumption (annual kWH), and annual gas consumption (annual gas btu)) are plotted on the y-axis[5]. Thus within each graph the median savings for a strategy type for a project is represented by four vertical points with each point representing the performance of each metric against the percent kW saved. Trendlines have been constructed for the performance of each metric.

Figure 1. Occupancy Sensor Control of Lights

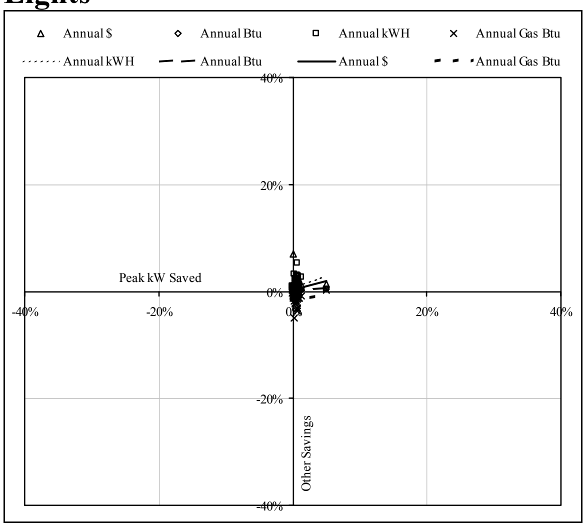
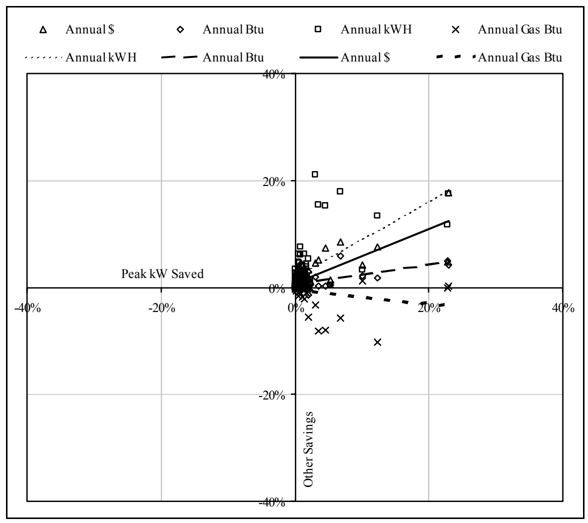


Figure 2. Variable Speed Drives on Motors



[4] Thus if seven glass types were modeled for a building, the glass type with the median value of kW savings is selected here to represent the glass type strategy for that building project.

[5] Some strategy types (such as occupancy sensors, lighting design in terms of reduced watts per s.f. and daylighting controls) affect applicable space types. Other strategy types (e.g. cooling efficiency) affect the whole building.

Figure 3. Efficient Lighting Design (w/s.f.)

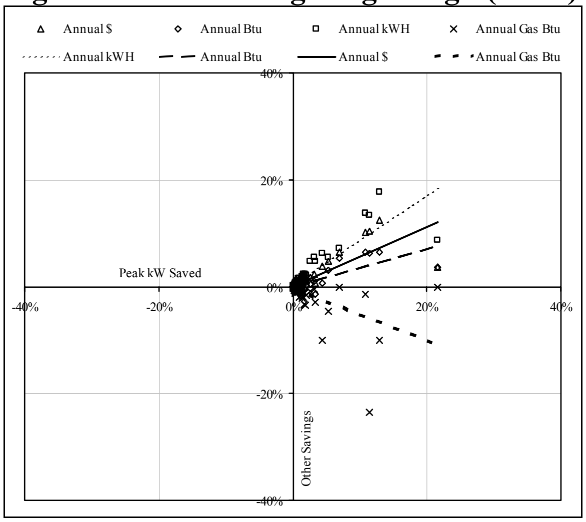


Figure 4. Motor Efficiency

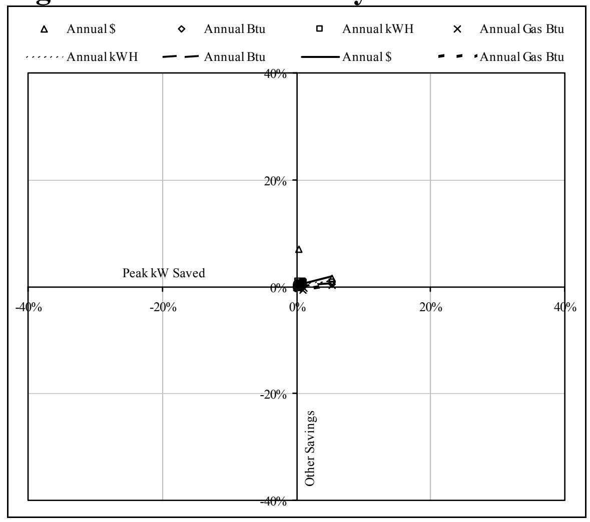


Figure 5. Chiller Efficiency

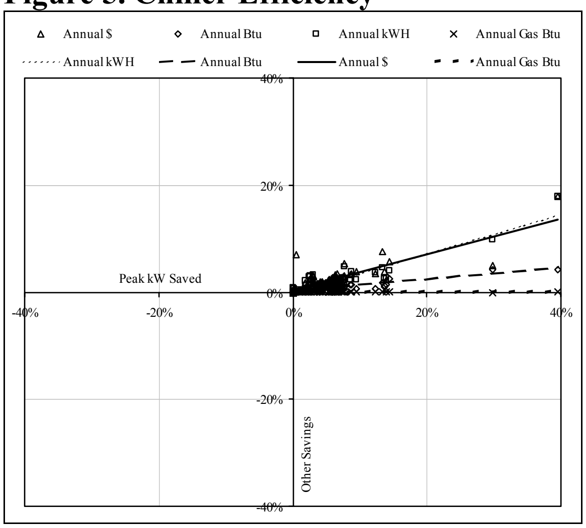


Figure 6. Heating Efficiency

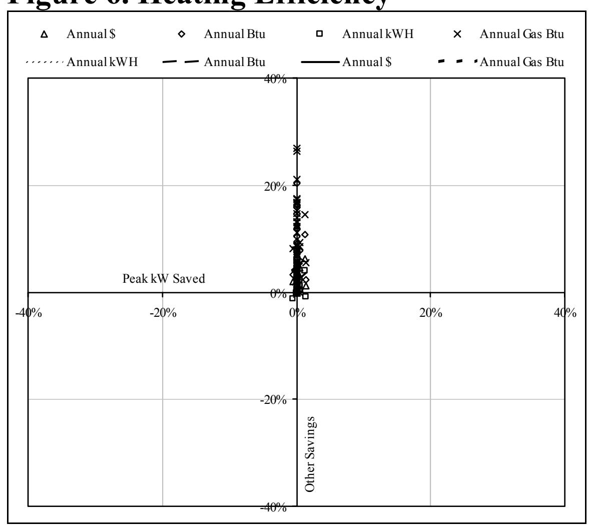


Figure 7. Glass Types

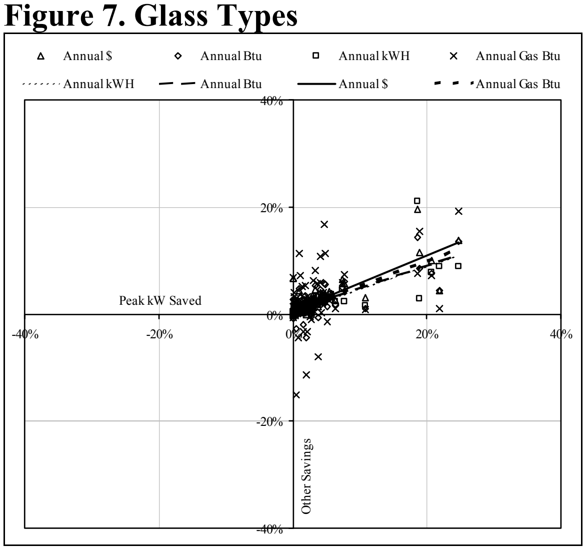


Figure 8. Daylighting Controls

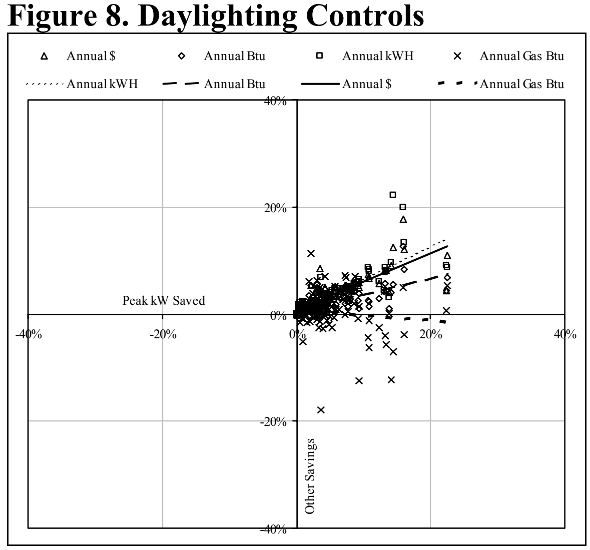


Figure 9. Outside Air Controls

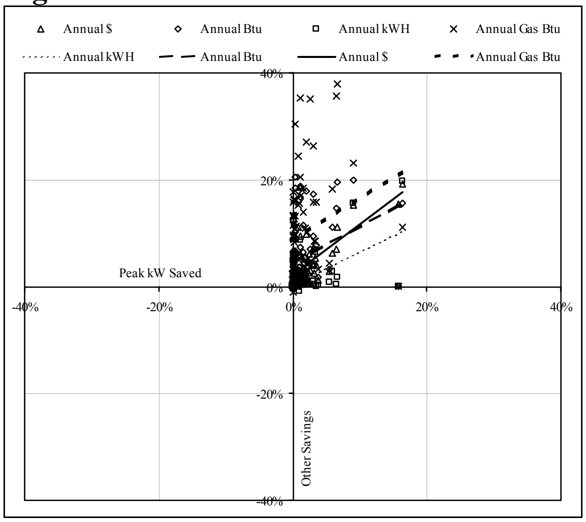
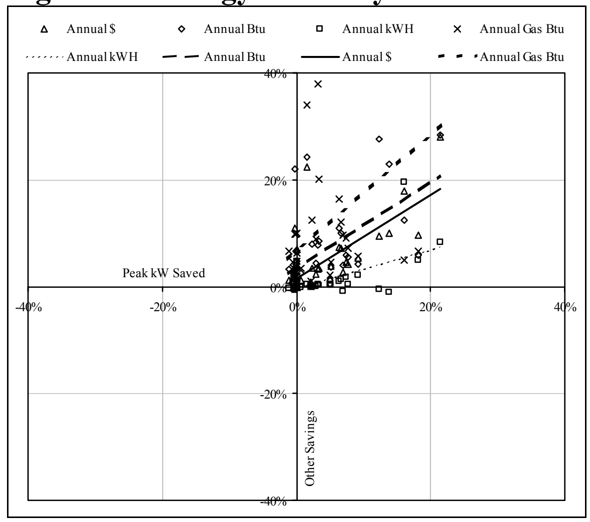


Figure 10. Energy Recovery



Figures 1-6 are strategies that are typically found in component rebate programs. These strategies represent the simple installation of specific equipment. Figures 7-10 are additional strategies that are typically a part of Energy Assets process but are not necessarily part of most component rebate programs. For all strategy types, the points cluster in the 0-5% range on the x-axis representing 0-5% savings for peak electric kW. Other than Heating Efficiency and Heat recovery the trendlines tend to have a slope less than 1, indicating that these strategies are biased towards savings on the x-axis (peak kW). For strategies that reduce internal heat gain such as lighting controls, daylighting controls and efficient lighting design, the trendline for gas consumption savings shows a penalty.

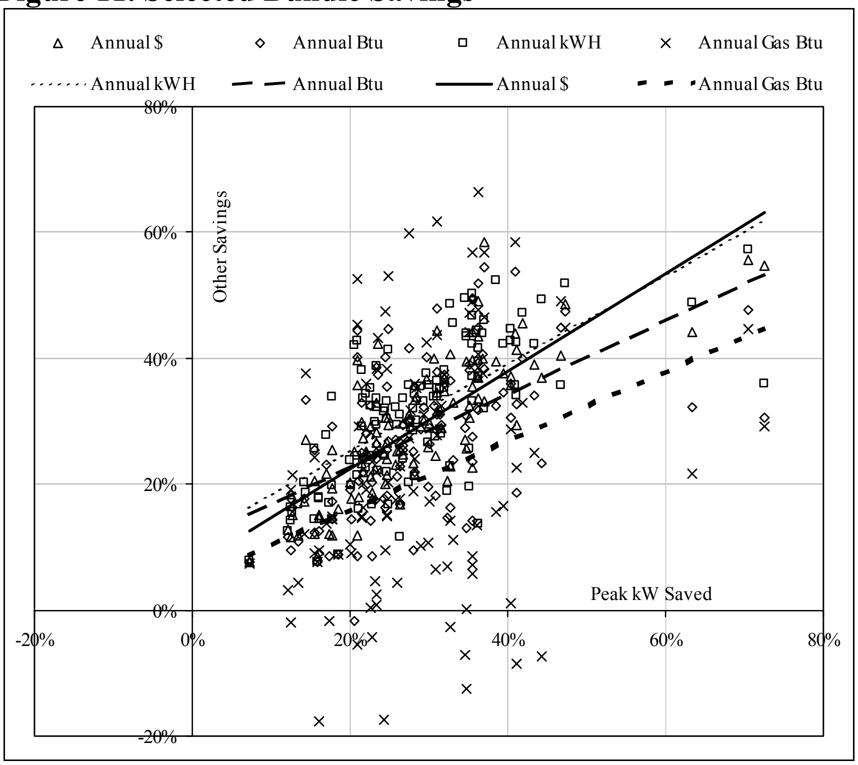
Figure 11 is similar to the previous figures 1-10 except it shows the savings for bundles of strategies that were selected by the designers and owners for implementation in 115 building projects of the program. Thus in this figure, the savings for the bundle represent the result of interaction between the strategies in each building. The four metrics are plotted against the percent peak kW and each project is represented by 4 vertical points.

In contrast to the individual strategy savings shown in figures 1-10 the bundles savings in figure 11:

- Show a distribution that ranges primarily between 15-45% on the x-axis and 0-50% on the y-axis.
- The trendlines do not show a penalty for gas savings.
- The trendlines for annual energy cost (annual $), annual operating energy at site (annual btu), annual electric consumption (annual kWH), have a slope close to 1. For these metrics, the selected bundles are not biased towards peak kW savings.
- The trendline for Annual gas consumption (annual gas btu) also has a significant positive slope though not as close to 1 as the other three metrics.

Since design teams make their choices on the bundle of strategies to be implemented based on the annual energy savings (annual $) and the peak kW savings (the utility incentives are based on peak kW), these show the best correlation. The compilation of a number of energy savings strategies that address different building uses, all of which are not biased towards peak kW, into strategy bundles, result in large savings that affect all fuel types. The savings represented in figure 11 are not expected of a demand savings program. The trendlines suggest a synergistic affect in the strategy bundles, where the gamut of strategies proposed in the analysis and final choices made by design teams have produced savings that go well beyond the perceived target of the program.

Figure 11. Selected Bundle Savings



Interacting with the Target Market

The open-ended consulting process allows designers and owners to be creative in suggesting their own additional strategies for analysis. This process brings together the architects, mechanical engineers, lighting designers, electrical engineers, cost estimators, contractors, building operators and owners to evaluate strategies for their energy performance and cost. The series of meetings allows collaboration between these different players to save energy and earn utility incentives. Each of them is compensated by the utility for their involvement. At the end of the design assistance process they are free to choose any of the strategy bundles, or they can simply continue to do what they had intended in the first place. Thus they come to the process free of risk. Underpinning the design process with solid energy information and adjusting the delivery to the design schedule are the key components of success of a project. As opposed to the installation of specific equipment required in a prescriptive style component rebate program, this design assistance program evaluates the value of an investment in a system on a project by project basis and encourages the designers, owners and building operators to get involved in the decisions and see tradeoffs between energy conservation measures. Over a period of time with multiple interactions with the design assistance program, designers and owners learn to incorporate cost effective conservation measures as part of their standard practice.

The Energy Assets program does not provide any technical assistance or training to the design community outside of the specific project interaction. It does not include showcasing nor is there any general design assistance service in the form of a design center. The program attracts participants through two mechanisms.

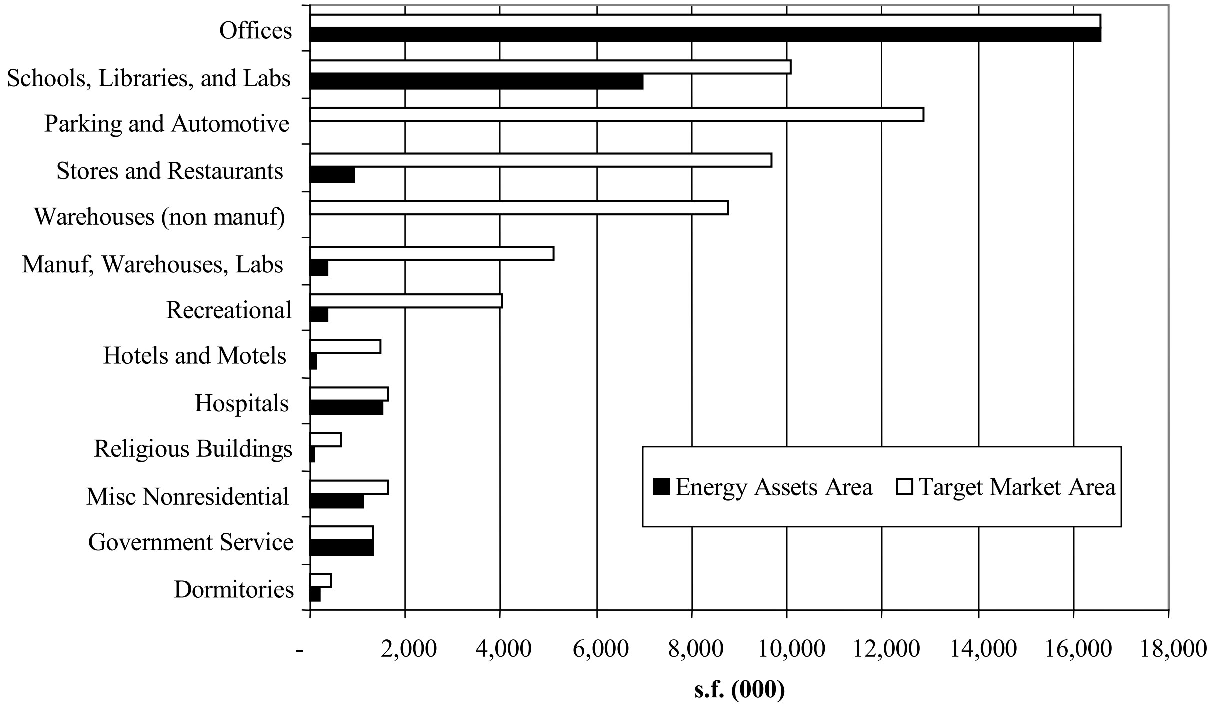
Firstly, a successful collaborative experience on one project fosters repeated participation on subsequent projects. The program is designed around the design practices of the architectural and engineering community along with their business concerns. By allowing a project team to implement a set of conservation strategies in which they have confidence, the success of a project creates it's own positive "word-of-mouth" form of marketing.

Secondly, the consultant firm used for the design assistance is also responsible for its marketing. Thus the success of the consulting firm is directly linked with the success and growth of the program. Individuals in the consultant firm have been active professionally, with positive reputations, in the design and construction community. The consultants develop relationships and market the program to individuals not firms, recognizing that for any project, it is the individual designers who elect to participate in the program rather firms (firm policy).

Market Penetration

The rapid program growth from 1997 through the present was a result of aggressive marketing efforts by the consultant firm that coincided with building construction-starts peaking in 1998 at nearly 30 million sq. ft. Average floor area constructed in Xcel Energy's service territory per year for 1997 to 2000 was nearly 25 million sq. ft. Buildings over 80,000 sq. ft, the target building size for Energy Assets, were about 63% of this total area, averaging nearly 16 million sq. ft. per year 1997-2000. Energy Assets addressed about 50% of its target market for 1997-2000 averaging more than 8 million sq. ft. per year. Office buildings and schools accounted for 78% of Energy Assets building area. Offices, including speculative office buildings, had the strongest growth with individual projects as large as 1.7 million square feet. The program, in terms of its service and the energy savings strategies developed, evolved as response to the dominant building types, like offices, schools and labs. Energy Assets process is now standard practice for many design firms in the area.

Figure 12. Energy Assets Market Penetration by Building Type[6]



Market Transformation

Design teams bring a proposed design[7] ('cost base' design) to the design assistance program; a few conservation strategies that reflect a design firm's typical practice are included. The energy design assistance process, in collaboration with the designers, evaluates roughly 70 strategies per project including the strategies already in the proposed design. The evaluation is based on explicit energy performance numbers from DOE2 simulations and construction first costs. Under the normal design/ construction process some of the strategies in the proposed design (cost base design) would be 'value engineered' out, and not implemented in the actual construction. Thus, cost base savings (savings of the initial proposed design compared to the code base) predicted in this study are a liberal estimate; the cost base does not necessarily represent the building that would have been built in the absence of the program. After evaluating the savings and costs of the 70 odd isolated strategies, 3 bundles of strategies that improve the savings beyond the cost base designs are created and simulated. The utility proposes incentives for implementing all bundles including the cost base (which is also considered a valid bundle), and the incentives are based

[6] The target market for Energy Assets has been commercial buildings with area greater the 80,00 SF in the Xcel Energy service territory in Minnesota. The target market was derived from F. W. Dodge database.

[7] The initial proposed design that the designers bring to the table in the design assistance process is considered to be the 'cost base' under the assumption that the few strategies that are included in this cost base design will have no incremental cost for implementation. Since the 'cost base' is defined as the base for comparing energy savings with added construction costs to determine payback, if a design team does not need to justify costs the costs of a strategy, it is included in the cost base, and cost estimating is not required, paybacks are not known, and it is assumed that this strategy was planned for all along.

on their peak kW savings compared to the Minnesota Energy Code base. Design teams choose a bundle of strategies for implementation (selected bundle)[8].

Figure 13. Savings for Cost Base and Strategy Bundles Selected for Implementation (Program-Wide)

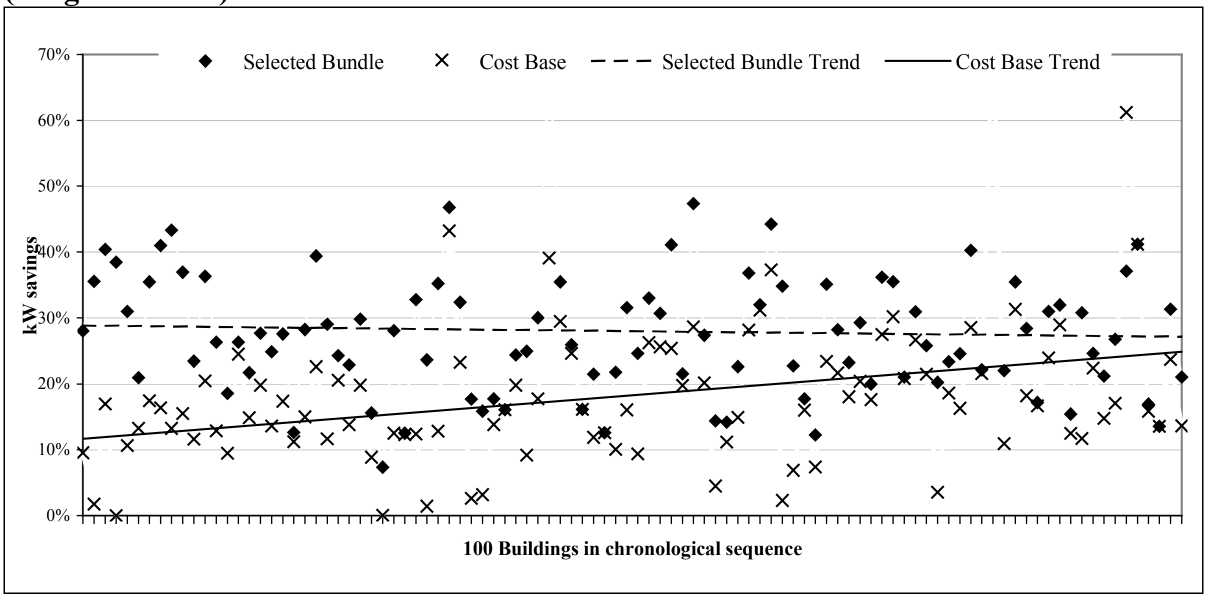


Figure 13 shows the peak kW savings for the cost base and the selected bundles. Over the years, the program has seen the cost base improve, compared to the energy code. If we assume that the cost base is, in fact, the "building as designed initially" by the design firms, we might conclude that,

- The program has been successful in terms of consistently delivering high performance buildings that have gone through the energy design assistance process, and,
- It has also been successful in causing firms to recognize cost effective strategies such that these firms have raised the level of their standard practice.[9]

However, the following factors need to be investigated to determine the magnitude of the real impact the program has had on raising the level of design and construction practices.

- Have design firms truly learned from the program, and do many of them now routinely seek to employ strategies now that they wouldn't have years ago?
- Beyond that, have some technologies become more mainstream over the years, such that the implementation of those technologies has outpaced implementation of more a aggressive code?

[8] In most cases the 'selected bundle' is one of the 3 bundles that have savings more than the initial proposed design (cost base design). However in a few isolated cases the designers/ owners have chosen to select the initial proposed design (cost base) for implementation.

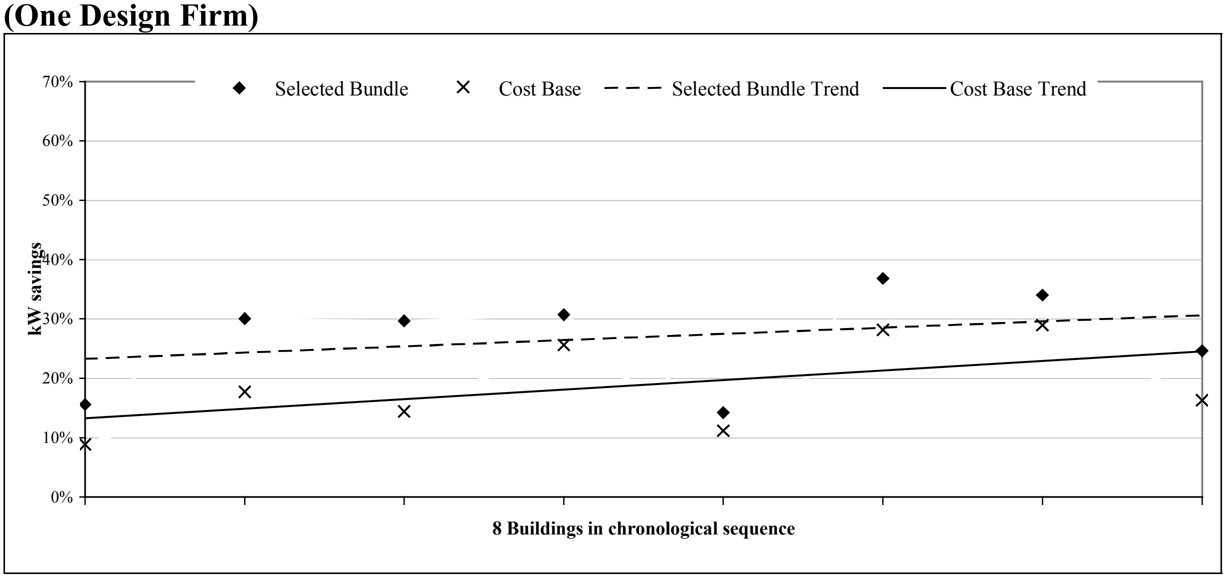
[9] Since all the bundles including the 'cost base' are compared to the Minnesota Energy Code base, the trend of increased savings is not due a modification in the energy code.

- Sometimes design teams define a good cost base at the start of the process (perhaps to impress their clients), knowing from past project experience that the energy savings combined with utility incentives for certain strategies make for good investment. So how far does utility incentive itself influence the inclusion of strategies in the cost base?
- In some cases, as the energy design assistance process ensues, the Cost Base often "creeps up" as the design team sees the obvious benefits of certain strategies. Strategies that were not in the cost base at the start end up there later, giving the appearance of a "good initial design." This creeping up of the cost base is more prevalent in the latter years of the program. How far does the "creep" explain the improvement in the cost base trend?

The selected bundle savings trend has remained relatively constant, even though we would expect, in a transformed market, that it would have improved. We argue the reasons for this to be:

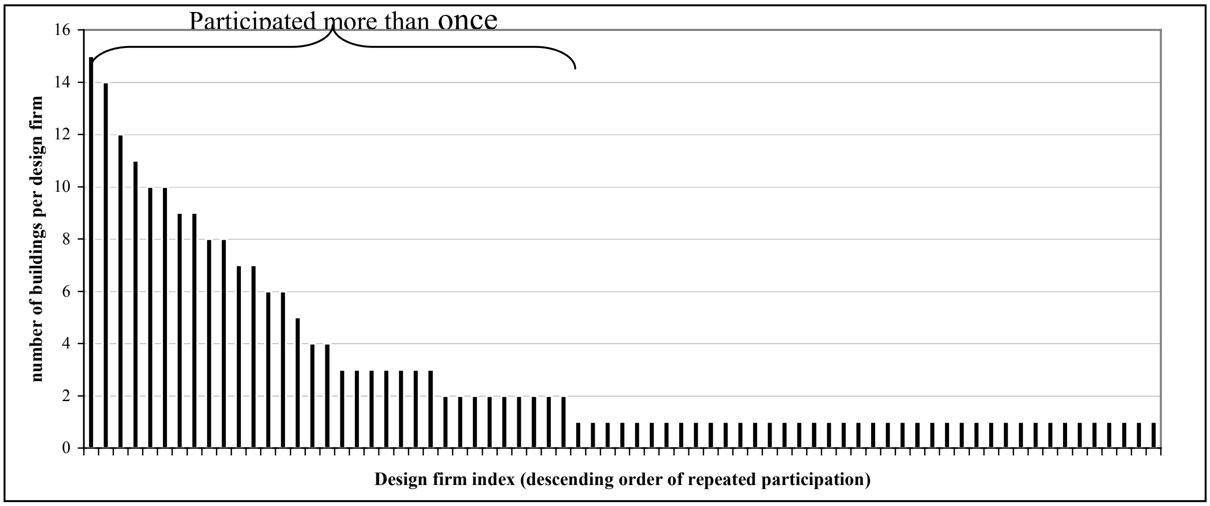
- Speculative buildings for office tenant occupancy (a building type generally not aggressive in terms of capital investment), were an increasingly larger portion of the program square footage in the late 1990's. While savings opportunities were identified, owners chose bundles that did not save as much as other building types.
- When design teams create bundles of strategies, they tend to be conservative and do not create the most aggressive bundle possible. While they may be more accepting of certain strategies over time to include them in the cost base, they do not correspondingly create and choose more aggressive bundles. It may be helpful if the energy consultants created an additional aggressive bundle as a way of showing the design teams the full potential of the strategies considered for a project.

Figure 14. Savings for Cost Base and Strategy Bundles Selected for Implementation (One Design Firm)



Design firms that have participated more often in the program have shown improvement in both their Cost Base and Selected Bundle (See figure 14). This tends to be the larger, more competitive firms. Figure 15 also shows that the program has a preponderance of buildings done by design firms who have participated repeatedly.

Figure 15. Repeated Participation by Firms



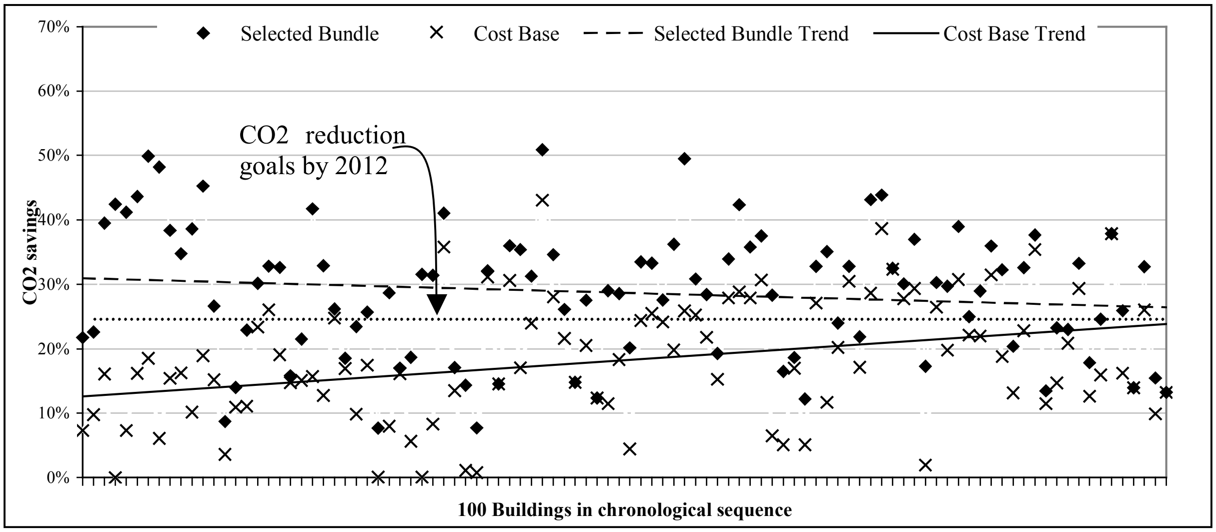
The program is now improving the offering in order to get more savings with the selected bundle for all participants. Beginning in 2002 the program includes:

- Progressive incentives that are significantly increased (per unit of savings) when savings levels are higher than the program average of 28%.
- Illustrative "best practice" bundles are shown as a target for Design Teams in evaluating their options.
- "Deeper" daylighting consulting is offered to realize savings through comprehensive design and specification.
- Increased emphasis is being put on researching and disseminating information on emerging technologies and strategies.
- Advanced energy design assistance is offered for selected demonstration projects, providing more detailed collaboration on building design and systems. These projects will serve as models for higher performance.
- The program will offer assistance with LEED™ energy compliance and documentation.

Impact on Carbon Emissions

Department of Energy (DOE) predicts commercial floor-space to grow by 1% per year through 2010. As per the Kyoto Protocol, the US would have required a 7% reduction from 1990 levels that translates to a 25% reduction for DOE's predicted growth by 2012. The Energy Assets program records a program average of 31% CO2 reduction compared to 1990 levels (the local energy code,) six percent more than the Kyoto requirement. Given this performance for mainstream buildings, along with ongoing market transformation and stimulation toward more savings with an updated program, the Energy Assets program serves as a model for building owners and designers in reducing CO2 emissions. If such programs were applied on a widespread basis in the United States, the Kyoto targets could be easily achievable for the new building construction market.

Figure 16. CO2 Savings for Cost Base and Bundles Selected for Implementation



Conclusions

Energy Assets, a demand side management program delivered through the vehicle of energy design assistance, has penetrated about half of the construction market that it operates in. The design assistance process has evolved around the dominant building types of the last decade, namely, offices, schools and labs. The open-ended consulting process used to encourage energy conservation measures has delivered savings beyond those expected from typical demand side programs that use component rebates. The average savings for peak and consumption for electricity, gas and district cooling and heating are in the range of 22 to 30% (compared to local energy code compliant buildings). Individual buildings often save as much as 45%. Through repeated interaction with the architects, engineers, developers and contractors in the local construction industry, this program may have significantly improved the standard construction practices.

Acknowledgement

We thank Julia Gauthier Xcel Energy for providing information about program costs, and John Weidt and Paul Reimer of The Weidt Group and Maithili Iyer of LBNL for their reviews.

References

ACEEE. 2000. Electric System Reliability and the Critical Role of Energy Efficiency. Washington DC. July 2000.

Gauthier, Julia. 2002. Personal communication.

Geller, Howard, Steven Nadel and Miriam Pye. 1995. *Demand-Side Management at Crossroads: Is There a Future for Electricity End-Use Efficiency in the United States?* In proceedings of ACEEE 1995 Summer Study on Energy Efficiency in Buildings.

Herzog Peter and June Wheeler. 1994-2000. Energy Assets Verification/Validation Reports for NSP (now Xcel Energy,).

Knittel, Christopher 1999. *Does Incentive Regulation Provide the Correct Incentives?: Stochastic Frontier Evidence from the US Electricity Industry.* Part of working paper series of the Program on Workable Energy Regulation. University of California Energy Institute. Berkeley CA. September 1999.

La Vine, Lance and David Grimsrud. 1999. *An Evaluation of the Energy Assets Program: A Report to Electric Marketing of Northern States Power Company.* University of Minnesota.

Lawless, Kevin. 1998. A presentation to American Institute of Architects (AIA) at the AIA MN convention, Fall 1998.

Vaidya, Prasad, David Eijadi, Tom McDougall and Jay Johnson. 2000. *Energy Assets[SM] Program and the Minnesota Design Community: Trends in Co-evolution.* In Proceedings of ECEEE 2000 Summer Study, 2:60-62.

Prowler, Don. 2001. "The 'Whole Buildings' Design Approach." *The Whole Building Design Guide.* March 26.