Center for Energy and Environment Multifamily Retrofit Program

Profile #97

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Executive Summary

The Center for Energy and Environment (CEE), located in Minneapolis, Minnesota, has implemented the Multifamily Retrofit program for Minnegasco since 1987. CEE, formally the Minneapolis Energy Office, a City agency, had extensive expertise in delivering efficiency services to residential customers and with Minnegasco developed a unique and effective means of providing gas efficiency services to multifamily building owners, a difficult but important market niche.

With the financial support of Minnegasco and beginning in 1981, CEE laid a solid foundation for the program by performing rigorous technical analyses of various gas saving retrofit measures coupled with field testing. These detailed analyses of load profiles, costs, and measured savings provided a sound basis for Minnegasco (and subsequently other utilities implementing similar programs designed by CEE) to be assured that their DSM investments are indeed cost effective and result in anticipated energy savings.

A second defining characteristic of the Multifamily Retrofit program is its basic orientation which fosters careful analysis coupled with education, rather than relying on enticing incentives for efficiency retrofits. Programs developed by CEE focus on convenience and responsiveness to customers – through a one-stop approach from auditing to financing to post-installation inspections – more than on the large rebates or other financial incentives. CEE believes that customers need to assume responsibility for their energy savings and thus must engage in training and ongoing maintenance activities to guarantee long-term savings, resulting in relatively low-cost utility programs with high participation rates and persistent energy savings.

The Multifamily Retrofit program primarily emphasizes upgrades to mechanical systems related to space and water heating. The program's focus has been on steam balancing, tune-ups, and vent dampers for steam-heated buildings, and on resets, cut-outs, and vent dampers for hydronically-heated buildings. More sophisticated measures – such as conversions from steam to hot water heating systems – are also made available through the program. To date, CEE and Minnegasco have teamed up to audit over 44,000 apartments in nearly two and a half thousand buildings and thanks to this effective program design, nearly 30,000 units have been retrofitted to date. Furthermore, since the program is reaching market saturation in Minneapolis, Minnegasco plans on expanding the program to encompass its entire service territory.

CENTER FOR ENERGY AND ENVIRONMENT
Multifamily Retrofit Program

Sector: *Multifamily buildings*

Measures: *Gas saving measures including steam balancing, boiler tune-ups, reset controls and cutouts, modular boilers, condensing water heaters, integral flue, thermal vent dampers*

Mechanism: *CEE contracted by Minnegasco to identify eligible building owners, to perform audits, and provide consultation, contractor selection, and post installation inspections*

History: *Program began in 1982; 2,348 audits conducted, 1,479 buildings have participated encompassing nearly 30,000 units in the Minneapolis area to date*

1993 PROGRAM DATA

Gas savings:	*19,200 MCF*
Lifecycle gas savings:	*211,200 MCF*
Cost:	*$96,323*

CUMULATIVE DATA (1987-1993)

Gas savings:	*749,108 MCF*
Lifecycle gas savings:	*1,390,708 MCF*
Cost:	*$768,647*

CONVENTIONS

For the entire 1994 profile series all dollar values have been adjusted to 1990 U.S. dollar levels unless otherwise specified. Inflation and exchange rates were derived from the U.S. Department of Labor's Consumer Price Index and the U.S. Federal Reserve's foreign exchange rates.

The Results Center uses three conventions for presenting program savings. ANNUAL SAVINGS refer to the annualized value of increments of energy and capacity installed in a given year, or what might be best described as the first full-year effect of the measures installed in a given year. CUMULATIVE SAVINGS represent the savings in a given year for all measures installed to date. LIFECYCLE SAVINGS are calculated by multiplying the annual savings by the assumed average measure lifetime. CAUTION: cumulative and lifecycle savings are theoretical values that usually represent only the technical measure lifetimes and are not adjusted for attrition unless specifically stated.

PROGRAM DESIGN, IMPLEMENTATION, AND EVALUATION

During the energy crisis of the 1970s, the City of Minneapolis, Minnesota became painfully aware that it needed to work to maintain its competitiveness as an economically viable city. To accomplish this, the City decided to form the Minneapolis Energy Office whose mission was to assist the City's businesses and residences in saving money by becoming more energy efficient and using resources wisely. The Minneapolis Energy Office was a City agency for roughly 10 years when in 1989 it changed its name to the Center for Energy and Environment (CEE) and became a non-profit organization. This evolution allowed CEE to expand its services and work with clients outside the City and state as well.[R#5]

CEE is now an energy service company that helps electric and gas utilities across the country to design and implement innovative, cost-effective energy efficiency and conservation programs for residential, multifamily, and commercial customers. Funding for CEE is derived from consulting projects, foundations, research organizations such as the Gas Research Institute, and utilities. The company has performed demand-side management and energy efficiency services for 15 years. Its staff of over 40 engineers, statisticians, research analysts, and program managers has delivered and developed energy programs across the United States and published more than 60 technical papers on energy efficiency.[R#2]

Programs developed by CEE focus on convenience and responsiveness to customers more than on the dollar value of incentives, and they stress the need for customers to assume responsibility for their own energy savings. The result for utilities is low-cost programs with high participation rates that achieve persistent energy savings. The measures included in CEE's programs are selected through technical analyses performed by CEE's research staff. Incentives and marketing strategies are designed by CEE's program experts to cost-effectively achieve energy savings by identifying energy saving opportunities for end-users to facilitate implementation.

Another focus for CEE is evaluating the processes and impacts of energy efficiency programs for utilities. Using metering devices, statistical methods, and evaluation techniques, CEE's research staff assists utilities in appraising their existing programs and identifying opportunities to improve them.[R#1]

FIELD TESTING AND DEMONSTRATION PROJECTS

CEE's applied research and evaluation projects are used in the design of energy programs. For instance, CEE has contributed 25 percent of the data points in the Lawrence Berkeley Laboratory's Buildings Energy Compilation and Analysis (BECA) database of multifamily retrofit research, and was among the first organizations to field test technologies such as gas engine-driven heat pumps and steam-to-hot water conversion of heating systems teamed with Minnegasco. For other clients, CEE also field tested efficiency tune-ups for commercial packaged air conditioning and foundation insulation.

CEE's research staff monitor equipment performance for the purposes of program design and evaluation. Over the past ten years, CEE has conducted more than 20 major field research projects involving end-use monitoring of gas appliances to quantify daily loads, time-of-day use patterns, energy efficiency and comparative energy savings. These projects have required the selection, programming, and installation of automated monitoring equipment including stand-alone data loggers with multiple input types and automatic, remote data retrieval.

In addition to research results, CEE contributes towards advances in field testing and monitoring methods. CEE develops techniques to streamline the process of data retrieval, archiving, display, and analysis. Staff determine the most cost-effective and accurate methods for monitoring appliances under specific field testing requirements. CEE staff also have validated the data quality requirements for the Princeton Scorekeeping Method (PRISM), an internationally recognized tool for weather normalization of energy consumption data.[R#3]

CEE places an emphasis on monitoring and metering of emerging technologies. CEE's staff are monitoring emerging gas technologies such as engine-driven heat pumps, desiccant cooling, double-effect absorption cooling, dual integrated appliances, and booster heaters for restaurants and food services. Load profiles of commercial cooking equipment as well as losses and seasonal efficiency of commercial space heating boilers and commercial water heaters have been conducted.[R#3]

TECHNOLOGY AND MARKET ASSESSMENTS

CEE designs and conducts technology and market assessments of end uses and customer segments on behalf of utilities and government agencies. In these assessments CEE takes advantage of its long standing working relationships with manufacturers, distributors, dealers, contractors, and engineering firms.

Results of technology and market assessments are disseminated at conferences such as the American Council for an Energy-Efficient Economy Summer Studies, the New Construction DSM Conferences, the Affordable Comfort Conference, and the American Society of Heating, Refrigerating, and Air Conditioning Engineers meetings.[R#4] ■

CEE designs and implements a wide range of DSM programs. CEE then transfers program designs and implementation strategies to utilities, community organizations, and government agencies nationwide. As a subcontractor, CEE has worked with utilities such as Ottertail Power, Northern States Power, Madison Gas and Electric, and West Penn Power. Through workshops and seminars, CEE helps train people on how to organize, market, and deliver energy efficiency programs. CEE doesn't provide incentives to customers for energy retrofits, rather they provide energy services. They do, however, assist customers in qualifying for and acquiring utility-financed rebates and incentives and in some cases can provide financing for retrofits.[R#1]

CEE along with Minnegasco designed and implemented the Neighborhood Energy Workshop (NEW) program as an alterative to providing energy audits to residential customers. The NEW program, a community-based energy program that teaches do-it-yourself house doctoring, achieves average gas savings of 7.3% by delivering educational workshops, energy audits, free weatherization materials, and hands-on training. In four years of the program in Minneapolis it has served more than 28,000 households (more than 25% of all households in 1-4 unit buildings) at a total cost of less than $80 per home. In Madison, Wisconsin the program was successfully expanded to add recycling, waste reduction, and water conservation components.[R#1,2]

Since 1984, CEE has provided full service residential programs for utilities ranging from energy audits, specifications, and construction management to low-interest financing and quality control for insulation, air sealing, high-efficiency furnaces and other improvements. Operation Insulation, for example, is a residential weatherization program provided by Minnegasco and CEE. The program has been highly cost effective to utilities because residents are persuaded to participate by convenience and quality assurance rather than by large financial incentives. Energy consultants conduct audits to inform homeowners of the most effective energy conservation measures for their homes. Thus, CEE provides a service to homeowners to facilitate a retrofit. CEE has delivered the program to more than 9,000 Minnegasco customers who have completed about $24 million worth of energy conservation work.

Project Choice represents pioneering work with low-income clients provided by CEE and Minnegasco. Within this program CEE coordinates with other agencies to combine energy education, budget planning, and client actions with subsidized weatherization to achieve energy use reductions of up to 25 percent. The program has been delivered to over 8,000 households in the Minneapolis metropolitan area alone.

CEE's Fluorescent Lighting Installation Program (FLIP) provides one-stop, direct installation lighting services to small business customers. Through the program CEE has delivered lighting audits, financing, and installation of high-efficiency T8 lamps and electronic ballasts to more than 500 businesses. Roughly 60% of all businesses contacted have participated in the program.

Moorhead Public Service, Minnesota's second largest municipal utility, is currently being assisted by CEE to develop and implement its first demand-side management plan. In a related project, CEE and Moorhead staff are producing a DSM manual to enable other municipal utilities to replicate the analysis and planning process developed by CEE.[R#1]

POLICY, PLANNING, AND OTHER ENVIRONMENTAL PROGRAMS

Aside from demand-side management services, CEE also works with investor-owned and municipal utilities to develop resource planning and demand-side management strategies. In coordination with a United Nations affiliate, the International Council for Local Environmental Initiatives, CEE has worked with the full spectrum of stakeholders to develop a carbon dioxide reduction plan for Minneapolis and St. Paul, as well as for the State of Minnesota. Other programs include a contract with the Metropolitan Airports Commission. Here CEE offers a comprehensive sound insulation program to residents near the Minneapolis-St. Paul International Airport. Also, CEE works with the City of Minneapolis on water conservation and solid waste programs and on a transportation demand management project funded by the State of Minnesota.

The subject of this profile is the program jointly provided by CEE and Minnegasco, the Multifamily Retrofit program. The emphasis of this program is on low-cost upgrades to mechanical systems, however lighting efficiency and weatherization are also addressed. Within this program CEE acts a conduit to implement energy efficiency measures in multifamily housing buildings. With the building owner fronting all the capital needed to retrofit his building, CEE provides the guidance and education needed to facilitate the retrofit. A crucial element of this program is the training provided to multifamily building boiler operators.[R#3] ■

MULTIFAMILY BUILDING BACKGROUND

Over 12 million dwelling units, nearly 15% of the U.S. total, are in multifamily buildings made up of five or more units. These buildings consume 800 trillion Btus of energy annually, over 10% of total energy use for residential buildings. Furthermore, the average energy intensity based on energy use per unit area of multifamily buildings is estimated to be 40% higher than that of single family homes, and their energy intensity for space heating is in the same range as single-family homes despite lower surface to volume ratios that might be expected to lead to lower energy intensities. Almost six million multifamily dwelling units in the U.S. are in buildings with central heating systems, and seven million are in buildings with central service water systems.

Improving the efficiency of multifamily buildings can contribute to national energy efficiency and to housing affordability, an especially important outcome since multifamily buildings are a major source of housing for low-income households. Despite these opportunities, in the years since the energy crises of the 1970s both research activity and utility and government programs have focused much less attention on multifamily buildings than on single family homes.[R#5]

Efficiency in multifamily buildings is not only quite a task but can also prove to be quite elusive. A significant fraction of the total fuel energy delivered to a multifamily building ends up somewhere other than in the heating distribution systems of individual apartments. In Minneapolis multifamily buildings for example, 20-40% of the total natural gas consumed on an annual basis is used for domestic hot water, and another 5% for gas ranges. Of the remaining 55-75% that is used by the boiler, 25-50% is lost up the flue or from the jacket, so that the useful heat produced by the space heating system is only 30-60% of the total gas bill. Of this, perhaps only as much as a tenth to a fifth goes to heat common areas.[R#13]

Though much more standardized in design and construction than commercial buildings, multifamily buildings present many of the same institutional challenges in terms of owners' very short investment horizons and strong aversion to financial risk. In CEE's initial contacts with multifamily buildings owners, staff found considerable suspicion about energy retrofits. In the early eighties, every salesperson seemed to have a device that would, "reduce energy bills by 25% with a one-year payback." Property owners lacked the technical expertise to distinguish truly cost-effective retrofits from "snake oil products." There was also a marked lack of multifamily retrofit research in technical literature. Most of what was available was in the form of case studies published by manufacturers in sales literature.

Since 1981, Minnegasco, the largest natural gas utility in Minnesota, and CEE have systematically field tested a wide range of retrofit strategies for low-rise, multifamily buildings. The focus of this work has not been on testing "way out" retrofits, but on measuring the actual performance of widely-recommended retrofits. These results provide a wealth of independent test data which can and has been used as objective bases for decisions by engineers, property owners, and utility demand-side management programs. These field strategies for multifamily building efficiency are the focus of this profile.[R#5]

Implementation

OVERVIEW

Minnegasco is mandated by the Minnesota Department of Public Service to implement natural gas DSM programs in its service territory. Minnegasco serves the multifamily sector by using CEE as their primary contractor. With Minnegasco's funding, CEE provides a "one-stop" opportunity for multifamily building owners. Through the service, building owners are provided with comprehensive services – from auditing and efficiency consultations, to product specification, contractor selection, financing, and post-installation inspections. In addition, CEE trains building maintenance personnel, an important ingredient for long term savings.

The Multifamily Retrofit program has not relied on direct incentives in the past. To date no monetary incentives have been provided to participants in the program. Instead the audit service and the subsequent energy efficiency consultations served as the impetus for building owners to make short payback energy efficiency improvements. However, beginning in 1995 Minnegasco plans on providing rebates of 50% of the full incremental cost of energy efficiency improvements (capped at $500) in multifamily buildings. For non-profit buildings, such as City-owned properties, Minnegasco has implemented a pilot program for heating system replacements that pays 100% of the full incremental cost of energy-efficient equipment. If approved by the Minnesota Department of Public Service, the non-profit incentives will be implemented system-wide in 1995 as well.[R#22]

The program has, and will continue to have, a financing element made available to participants through CEE. With funding from the Minnesota Housing Finance Authority and some petroleum overcharge funds from the Minnesota Department of Public Service, CEE administers the state's Energy Bank for the Multifamily Retrofit program as well as other residential programs. Staff have found that multifamily building owners typically take advantage of this low-cost financing about 30% of the time, in contrast to other residential programs where the financing uptake approaches 90% of the time. (CEE's two full-time equivalent staff that manage The Energy Bank process and underwrite about 1,000 loans each year.)[R#11]

MARKETING

When the program first started in the early 1980s, CEE staff segmented the multifamily market in various ways to "target market" to this sector for the first time. Using information obtained from the City of Minneapolis assessor and lists from the Minnesota Multi-Housing Association (MHA), a list of building owners was developed and then divided by building type: hot-water heated and steam-heated being the largest sectors. Marketing was then designed to target these building types, highlighting typical problems these owners encountered and solutions possible through the program. Direct mail marketing was then used. The direct mail package targeted each type of owner. For example, owners of multiple buildings were sent a mailing including a testimonial from the MHA.

Seminars were held in various parts of the City. Typically a continental breakfast was served and 15 to 30 owners attended. After a slide presentation and model demonstrations of such technologies as boiler controls, building owners were scheduled for audits for their buildings. Each seminar was designed to appeal to a particular type of owner's self interest. For example, some seminars dealt with meeting state codes, lowering maintenance costs, or improving their cash flow.[R#11]

After marketing to this same sector for over ten years CEE has changed its marketing approach quite a bit. CEE now relies more on networking. Use of the MHA, word-of-mouth, and collaboration with former customers are incorporated in the "marketing toolkit" to uncover new building owners to participate in the Multifamily program. Also, over the years the technologies addressed have been updated as research has been completed on this sector and findings have been incorporated into the program.[R#11]

DELIVERY

The audit: The process begins with a comprehensive site visit to the building, its apartment units, and all common areas to examine heating and domestic hot water equipment, lighting, and virtually any other opportunities for energy savings. A complete report is then written up and a computerized report is completed including the site information and analysis of the building's gas usage. An important part of the site visit is training of the maintenance personnel on boiler controls. If controls are installed as a part of this program the auditor performs this training during the post installation inspection.

While most multifamily buildings might only be in need of exit and hall lighting retrofits, CEE still attempts to qualify an owner for any lighting retrofit rebates tied into the local electric utility. In most cases a multifamily building doesn't require enough lamps to warrant a rebate. CEE does not account for or receive credit for any electricity savings accrued within the multifamily program.

Consultation: Next, the audit results are presented to the owner including firm costs of the retrofits. The owner can actually sign up to get the work done during the consultation appointment, including filling out the loan forms since CEE offers low interest financing to rental owners.

Work Completion: If the owner elects to carry out the work using a CEE-certified contractor, CEE assigns the job on a rotating basis, and then sends the completed paper work to a contractor that has been screened and trained to do the installations recommended using the specified equipment.

Post Installation Inspection: Work done through the Multifamily program is inspected for quality control. Insulation work is inspected with an infrared camera. Other work has a visual inspection and/or review of the contractor's report and invoice. Once a contractor has installed a certain number of boiler controls for the program, 100% of their installations are not inspected, but rather done on a random basis. Also during the post installation inspection the training of maintenance personnel is completed when needed.[R#11]

CEE RETROFIT STRATEGIES FOR STEAM-HEATING SYSTEMS IN MULTIFAMILY BUILDINGS

The success of technologies suggested to multifamily building owners in this program is based upon field tested DSM strategies that provide a reliable basis for multifamily program design. These strategies for both steam and hydronically-heated buildings as well as hot water services include: 1) boiler tune-ups, 2) vent dampers, 3) steam balancing, 4) steam to hot water conversion, 5) outdoor reset controls, 6) energy cost allocation, 7) front-end modular boilers, 8) condensing commercial water heaters, 9) service water recirculation loop control, and 10) commercial water heaters with integral flue dampers.

Providing Boiler Tune-ups for Multifamily Buildings: A boiler tune-up is a technique whereby adjustments and cleaning is applied to boilers to make them more efficient. This is especially applicable to older boilers.

One goal of a tune-up is to decrease excess air and reduce stack temperature. Modifications completed consist of reducing secondary air directly by adjusting the manual or motorized draft louvers control, uprating or derating the input, installing flue restrictors for more uniform air flow, sealing leaks around doors and the combustion chamber, cleaning the fire-side of the heat exchanger to eliminate carbon build-up, cleaning the water-side of the heat exchanger to eliminate scale build-up, and in the case of a steel-fired tube boiler, installing tubulators.[R#8]

CEE has attempted to train contractors to complete tune-ups using the proper equipment and techniques to make this service more widely available. In addition, efficiency increases due to the tune-ups were measured and compared with predicted increases, and boilers were re-tested several months after the tune-ups to examine stability of the modifications.[R#8]

CEE field testing of boiler tune-ups found that combustion efficiencies improve with tune-ups from an average of 79% to an average of 82.5%. Energy savings determined from CEE field testing ranged from zero to 14.3%, with an average of 3.9%. This converts to annual dollar savings ranging from $159 to $354 per building, depending upon the type of tune-up needed. Paybacks ranged from 0.2 to 4.1 years, with an average of 1 year.[R#5,8]

Vent Dampers: An automatic vent damper is a device which is installed in the vent of a fuel burning appliance. It is ☞

installed downstream of the draft diverter or barometric damper and closes automatically when the burner goes off to reduce the flow of air up the chimney during the off cycle.

Vent dampers can reduce fuel use in two ways. The first is to reduce heat loss due to air flow over the heat exchanger. This air flow itself may actually be reduced, but more typically most or all of the air flow is maintained, with the damper causing it to spill through the draft diverter into the space around the furnace or boiler rather than exit via the chimney. It can then potentially provide useful heat gain to the building. The second mechanism is to reduce the building infiltration rate by eliminating part of the normal escape of warm house air through the chimney during the off-cycle.[R#9]

CEE's field testing of low rise apartment buildings showed that savings vary greatly for boiler damper only and boiler plus water heater damper retrofits. Average total building gas savings of 8.6% were determined for boiler damper only buildings with converted coal to gas steam boilers. Costs range from $1,527-2,721 with an average payback of 2.2 years.[R#5,9]

Steam Balancing in Single Pipe Steam Buildings: The worst source and almost universal cause of energy waste in single pipe steam (SPS) heated buildings is inadequately designed control and distribution systems causing uneven heating in older buildings, typically built prior to World War 2. To minimize complaints from cooler areas of the buildings, owners are forced to grossly overheat other areas, leading tenants to open their windows for relief. This opening of windows to cool down overheated apartments even in the coldest weather was part of the original design and normal operation of the buildings. This causes serious energy waste in older steam heated apartment buildings, a common problem in Minneapolis. Rebalancing can reduce space heating costs by as much as 15 to 25%. The SPS system is inherently the most difficult to balance and control. The thermostat is generally adjusted to satisfy the coolest apartment, with the result that other apartments are overheated by as much as 10 to 15°F.[R#10]

Balancing a heating system means reducing the temperature difference between warm and cool apartments. Tenant comfort can be increased and the thermostat setting can be reduced at the same time. In the simplest terms, the major cause of uneven heating is that the boiler provides more heat to some radiators than to others. This happens for several reasons: large differences in steam arrival times, excessively short boiler cycles, lack of zone control, improper radiator sizing, and improperly sized distribution piping. The radiators furthest from the boiler often receive steam 15 to 25 minutes later than the radiators closest to the boiler, both due to the large thermal mass of the distribution system relative to the boiler input rate, and due to the low pressure operation. The heat anticipator on this type of thermostat shuts the boiler off long before steam reaches the apartment in which it is located. The system thus operates in repeated short bursts which continually fill the near radiators but only fill the far radiators once every few cycles.[R#5,10]

CEE's field testing has resulted in the development of a strategy for balancing steam distribution. Installing a thermostat with an adjustable differential and no anticipator, and adding very high capacity mainline air vents and radiator air vents, reduces total building gas use by an average of 10% with a median payback of 1.3 years.[R#5]

Conversion from Steam to Hot Water Heating: Steam to hot water conversion is the practice of replacing the steam heating system in an older building with a hot water heating system. A steam to hot water conversion is more energy efficient for a number of reasons. First, steam heated buildings are notorious for uneven heating. Keeping the coldest apartments warm, typically means overheating the rest of the building. A hot water system is easier to control, resulting in more consistent heat and average space temperatures that may be lower. Second, large uninsulated steam distribution pipes lose heat into basements and other areas where it is often not needed. Since hot water is circulated at a lower temperature than steam, piping losses in a hot water system are expected to be lower. Finally, the higher operating temperatures of a steam boiler produce greater jacket and stack losses, reducing overall seasonal efficiency. Thus, seasonal efficiency of a boiler may be higher if it is used to produce hot water rather than steam.[R#12]

The work done in converting from steam to hot water depends primarily on the building's existing piping system. In two pipe steam (TPS) systems, where there are separate steam supply and condensate return pipes for each radiator, the existing distribution system and radiation is nearly always retained, which makes conversions relatively easy and inexpensive. In single pipe steam (SPS) systems, where each radiator is connected to a single pipe which both supplies steam and carries away condensate, a considerable amount of new piping and new radiation is needed. Since SPS conversion is so extensive, other changes are made to allow the building to be zoned. Since most of the piping and radiation is being replaced anyway, it is relatively easy to redesign the pipe layout so that each apartment has its own distribution loop, with a single inlet and outlet. A thermostatically controlled zone valve can then be installed on the inlet to allow individual control of the apartment temperature. All of these changes make SPS systems much more expensive and difficult to convert. In the Twin Cities housing stock as a whole, only about a fifth of the steam buildings are TPS.[R#12]

In nearly all cases the boiler is also replaced. Contractors state that while boiler replacement is not always necessary as part of the conversion process, they usually recommend it if the owner has the money available. In general, contractors feel that old steam boilers are inefficient, oversized, and have a short life expectancy.[R#12]

CEE's field tests of this retrofit showed that buildings converted saved an average of 27% of total weather normalized gas use for a two-pipe steam system and 18% for a single pipe steam system. Costs are rather high averaging $27,800 for a TPS and $57,600 for a SPS system. While the payback is long, sometimes exceeding 20 years, steam to hot water conversion offers other compelling advantages in terms of improved tenant comfort and system reliability, lower maintenance costs, and increased building resale value.[R#5,12]

CEE RETROFIT STRATEGIES FOR HYDRONIC-HEATING SYSTEMS IN MULTIFAMILY BUILDINGS

Outdoor Reset Controls: Hydronically-heated apartment buildings normally have one or more main heating distribution loops from which separate baseboard loops run into each apartment. A pump circulates hot water through the main distribution piping continuously. Each apartment has a zone valve and thermostat to regulate the flow of hot water into its baseboard loop. In the majority of these buildings in Minneapolis, the boiler is controlled by an aquastat which keeps the water in the system at a constant temperature.[R#7]

The amount of heat given off by baseboard radiation depends on the temperature of the water circulating through it. Buildings are typically designed so that a water temperature of 180 to 200°F is required to balance the apartments' heat loss at the coldest winter temperatures. This water temperature is much higher than is needed for most of the winter, resulting in extensive unused energy.

To solve this an outdoor reset control can vary the temperature of this water in the distribution system inversely with outdoor temperature, so that the minimum temperature necessary to heat the building is provided.

Additionally, an outdoor cut-out can shut off the circulating pumps and prevent the boiler from firing when the outdoor temperature is warm enough that no heat is needed. Many hydronic heating systems are started manually in the fall and turned off manually in the spring. Between these dates the pump operates continuously and the burners cycle to satisfy the demands of the aquastat or reset. It is not practical for the maintenance person to stop and restart the boiler for every mild period, so the common practice is to allow it to run. An outdoor cut-out deals with this problem by sensing the outdoor temperature and automatically shutting off the burners and pump whenever heat is not needed. Cutout settings of 55°F were found to be suitable in the test buildings.[R#7]

CEE's field tests of these technologies in multifamily buildings have shown that when reset controls and cut-outs were alternated with constant temperature control and manual cutoff on cast iron boiler, annual savings average 18% of total annual space heating costs. This results in a dollar savings ranging from $159-1,393 per year. The reset and the cut-out together cost $450 installed, so the payback is often less than a year.[R#7] ☞

Energy Cost Allocation: Energy cost allocation systems are combinations of monitoring devices and accounting procedures designed to allow the energy costs in centrally heated multifamily buildings to be divided among individual apartments on the basis of use. Energy cost allocation has several potential benefits. First, from the property owner's perspective, allocation is one way to remove the highly variable cost of energy from building cash flow. Second, allocation of energy costs to residents typically reduces energy use by 10-25%. Third, allocation may sometimes be preferable to installing individual heating systems in each apartment.[R#13]

A variety of types of metering devices used for allocation are on the market today. Elapsed time meters are probably the most common type of cost allocation equipment in the U.S. These do not actually measure the amount of heat or cooling delivered, but rather provide an estimate by recording the number of hours the apartment thermostat calls for heat, the number of hours the zone valve is open, or the number of hours the fan of a fan coil unit is on. Time metering systems now cost from $120-300 per apartment installed.[R#13]

Thermal (or Btu) meters are much more expensive than time meters, costing from $250-800 per apartment installed. However, these actually determine the amount of heat delivered to each apartment by measuring mass flow and inlet and outlet temperatures.[R#13]

A savings of 16% of total gas use with a payback of 1.4 years results simply from giving residents direct responsibility for energy costs.

Front-End Modular Boilers: Modular boilers are several sequentially-fired, smaller-sized boilers or "modules" used in multifamily buildings instead of one large boiler. This concept is not new and has several advantages including the availability of backup, the ability to directly reset boiler water temperature, and the physical ease of installation and maintenance. In addition, the individual boilers in such a design can be operated or turned off as needed to meet the building load. This results in lower standby/off-cycle losses and should potentially be more efficient than a single large boiler that is sized to meet the heating demands of the building under design conditions.[R#14]

A front-end boiler (FEB) borrows from the modular boiler idea. A FEB is a high efficiency boiler installed in tandem with a larger, existing space heating boiler and sized to meet the heating load of the building during mild weather. The potential benefit of this design stems from the fact that in cold climates most of the annual heating energy consumption actually occurs at moderate temperatures. In Minnesota, a front-end boiler sized to meet 25-50% of the maximum demand will meet 60-90% of the annual load. The original boiler only operates to meet the heating load for the relatively small amount of time that the FEB cannot meet the load. During these times, the FEB can either run constantly to provide a base level of heat input or be turned off. A FEB can also be designed to heat domestic hot water.[R#14]

Field tests by CEE have shown that savings from FEB average around 5%, although savings of over 20% have been acquired for particular retrofits. Costs for the installation of an FEB range from $25,000 to $53,000, averaging $39,833, depending upon the size of the boilers. Broken down, the prices range from $6,250 to $10,600 per boiler. Paybacks range from 6 years to 24 years, with an average payback of 12.8 years.[R#14]

RETROFITS FOR SERVICE HOT WATER

Condensing Commercial Water Heaters: Hot water heating accounts for 15 to 27% of the total energy use in Minneapolis apartment buildings, not counting the energy used for lighting and domestic appliances. In multifamily buildings this retrofit consists of replacing existing conventional tank-type hot water heater boilers with high efficiency condensing water heaters estimated at 90% thermal efficiency.[R#15]

Historically, most boilers used for hot water heating were non-condensing, meaning that the water vapor in the flue gases was not condensed in the boiler or the flue pipe. On cold days this water vapor appears as white steam emerging from the flue pipe outlet. By condensing this water vapor a great deal of useful heat can be recovered from the flue gas, improving boiler efficiency.[R#18]

To capture the latent heat from water vapor in the flue gas, condensing boilers allow the flue gas moisture to condense and drain out safely. The condensing components of these boilers are constructed from materials such as stainless steel that resist the corrosive effects of the condensate. Not only does this enhance efficiency by capturing the heat released in condensation, but also the cooler return water is better able to absorb heat from the burner, loses less heat to the surroundings, and produces cooler flue gases.[R#18]

Installed costs for the high efficiency condensing hot water heater range from $2,800 to $3,500. As a result, even with savings of 28%, paybacks based on total costs are 23 to 27 years. Paybacks like this are no inducement for an owner to replace a working hot water heater with a high efficiency unit. Even in the case where a new hot water heater is required, the added cost of the high efficiency heater is substantial, and paybacks are only reduced to about 19 years, still much longer than most owners are willing to accept without some sort of additional incentive. However, paybacks will improve as larger units, applicable to buildings with a higher annual domestic hot water demand, become available.[R#15]]

Service Water Recirculation Loop Control: A major factor in domestic hot water energy use for apartment buildings is the presence of a return piping system, common in buildings of 40 units or more with central water heaters. In this system, hot water is constantly recirculated through a supply loop so that it is readily available at taps, preventing a long wait for hot water to be drawn from the water heater to remote parts of the building. Usually uninsulated, this supply loop can be a large source of heat loss.[R#16]

One tactic to reduce recirculation pipe loss is to insulate the loop. While appropriate in new construction, this is impractical as a retrofit since recirculating lines in existing buildings are usually inaccessible. Another strategy is to reduce supply temperatures to the minimum acceptable.

Domestic hot water use shows very strong hourly fluctuations. As a result, another way to reduce loop loss is to turn off the recirculating pump during periods of low demand, such as in the night. The disadvantage is that tenants who need hot water during periods when overall demand is low will face a long wait. An alternative is to reduce the supply loop temperature during times of light demand.[R#16]

Controls that provide automatic temperature adjustment range from mechanical timers with fixed set-up and setback temperatures and times, to complicated electronic controls with internal memory that can "learn" patterns of domestic hot water use, anticipate demand, and adjust the temperature setting accordingly.[R#16]

Time controls for multifamily buildings cost from $900 to $1,000. Demand controls cost around $1,400. CEE's field tests of this measure showed mean annual savings of 10.3% with an average payback of 2.2 years. By comparison, a demand-based control demonstrated average savings of 16.2% and had a mean payback of 1.9 years. For the timer controls, 80-90% of the savings appeared to be the result of reduced pipe and off-cycle losses, whereas for the demand control, 30-70% of the savings can be attributed to these reductions. The remainder of savings in both cases can be ascribed to reduced demand due to fixed temperature uses.[R#16]

Commercial Water Heaters with Integral Flue Dampers and Thermal Vent Dampers: Standby losses for commercial tank-type water heaters (including stack and jacket losses) can account for as much as 13% of the total energy used to heat domestic hot water in apartment buildings. Potentially, losses up the stack could be reduced by retrofitting existing heaters with automatic vent dampers, or by replacing them with water heaters equipped with integral flue dampers.

A vent damper is a device which is installed downstream of the draft diverter to reduce air flow up the chimney during the off-cycle. Vent dampers can save energy in two ways. First, they reduce building infiltration by eliminating one escape route, the chimney, for heated building air. Second, they ☞

reduce heat loss due to air flow over the heat exchanger itself.[R#17]

One of the few high efficiency upgrades available on a standard commercial tank-type hot water heater at the time of purchase is the option of an electric integral flue damper (IFD). In contrast with a vent damper, and IFD is factory-installed upstream of the draft diverter, which reduces stack related standby losses by retaining the maximum amount of heat inside the heater itself. As a result, savings potential for an IFD may be much larger than for a vent damper since warm air spilled into the boiler room by a standard vent damper may or may not be useful to the building.[R#17]

CEE's field testing showed that savings from this type of water heater were small enough that it did not prove cost-effective. Savings were about 4-6%, corresponding to annual energy reductions of 11-13 MBtu. Domestic hot water heaters with IFDs cost about $2,600 to $2,800 installed. As a result, paybacks for replacement of a working water heater are well over 30 years. On the other hand paybacks based on the marginal cost of an IFD heater over a conventional heater were about 10 years, well within the expected lifetime for a heater of this type. As a result, this is a good heater to recommend at the time of required replacement. By comparison, tests of thermal dampers installed on heaters showed no efficiency improvement and no savings potential.

STAFFING REQUIREMENTS

CEE's is staffed by a total of 40 persons. The Multifamily Retrofit program requires roughly three full-time equivalents to run the program, though much of the analysis and research that supports the program was carried out by other staff over the years. Currently an auditor averages six hours per building to complete a site visit, gas data analysis, work write up, consultation with the owner, and post installation inspection and training. In addition, one to two hours is spent coordinating the work with the contractor and owner or maintenance personnel. This installation management is done by non-auditing staff at CEE. The contractor's time spent on the installation varies greatly with each installation. However since mostly low-cost upgrades are recommended, generally installation time is only a few hours.[R#11]

At Minnegasco, the program is administered by one full-time equivalent. Additionally, a roster of contractors and vendors are directly and indirectly involved with the program.

MONITORING

No post metering or monitoring is performed by the Center for Energy and Environment for the multifamily buildings that have been retrofitted under the program. However, a post-installation inspection of various measures is performed to guarantee that retrofits are completed correctly. Tracking of energy savings is based upon estimates derived from the field tests discussed previously. More specifically, as shown in the Participation and Savings Overview tables in the next section, an average savings of 10% based upon the CEE's Multifamily Pilot Project was used to calculate a building's total energy savings after a retrofit. This 10% is extrapolated out for all of CEE's retrofits.[R#19]

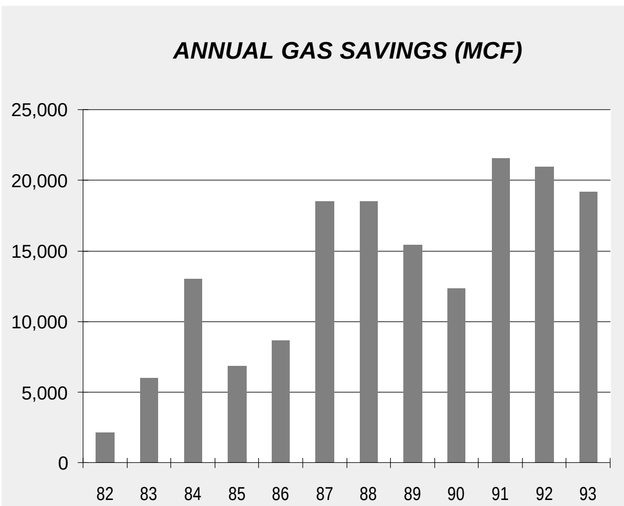
EVALUATION

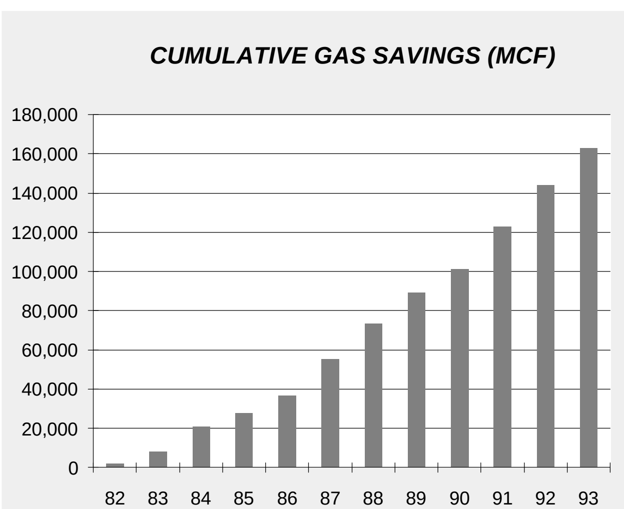
Since 1981, CEE has performed numerous evaluations or "field tests" of efficiency strategies for the installations of each type of retrofit measure for a given number of steam and hydronically-heated multifamily buildings. Each evaluation began with a history of the building's former measures along with a description of efficient measures to be installed. The focus of the evaluations was to provide baseline energy consumption patterns, discuss the most efficient technologies, determine the energy savings and costs to the building owners and tenants, and calculate average paybacks. ■

Data Alert: Annual gas savings for CEE's Multifamily program are estimates based upon CEE's Multifamily Pilot Project in which outdoor resets, cut-outs, and steam balancing were implemented, resulting in average savings of 10% of total building usage. Minnegasco is currently conducting a billing analysis that will assess the actual performance of the program.

SAVINGS OVERVIEW	GAS SAVINGS (MCF)	CUMULATIVE GAS SAVINGS (MCF)	LIFECYCLE GAS SAVINGS (MCF)
1982	2,157	2,157	23,727
1983	5,977	8,134	65,747
1984	13,002	21,136	143,022
1985	6,840	27,976	75,240
1986	8,688	36,664	95,568
1987	18,486	55,150	203,346
1988	18,486	73,636	203,346
1989	15,405	89,041	169,455
1990	12,324	101,365	135,564
1991	21,567	122,932	237,237
1992	20,960	143,892	230,560
1993	19,200	163,092	211,200
Total	163,092	845,175	1,794,012

Gas savings resulting from CEE's Multifamily Retrofit program began in 1982 with over 2,157 MCF saved. Annual savings steadily increased for the next ten years reaching a maximum savings in 1991 of 21,567 MCF. Savings in 1992 and 1993 declined slightly from 21,567 MCF to 20,960 MCF and 19,200 MCF respectively. However, while 1992 and 1993 gas savings decreased 3% and 9% respectively, those years also had significantly less building installations, resulting in 40% higher savings per building. In 1992 and 1993, estimated gas savings of 160 MCF per building resulted, surpassing the prior average, annual savings of 103 MCF per building. Since most buildings have 17 to 24 units, the historical annual savings per unit is estimated to be 4-6 MCF.[R#22]





In 1993 the program resulted in estimated annual gas savings of 19,200 MCF, cumulative gas savings of 163,092 MCF, and lifecycle energy savings of 211,200 based on an 11-year average measure life. Total cumulative gas savings for the program to date equal 845,175 MCF, with projected lifecycle savings of 1,794,012 MCF. Electricity savings resulting from measures recommended within the Multifamily Retrofit program are not accounted for by CEE.

PROJECTED SAVINGS

Since the program has reached diminishing returns in terms of completions, CEE is currently working with Minnegasco to service their customers outside the metro area. Thus the program's overall level of participation is not anticipated to change significantly and annual savings are expected to remain relatively constant. ☞

PARTICIPATION	AUDITS PERFORMED	UNITS AUDITED	BUILDINGS INSTALLED	AVERAGE UNITS PER BUILDING	UNITS INSTALLED	SAVINGS PER BUILDING (MCF)
1982	35	827	21	24	504	103
1983	97	2,318	58	24	1,392	103
1984	211	4,622	127	22	2,794	102
1985	111	2,220	67	20	1,340	102
1986	141	2,820	85	20	1,700	102
1987	300	5,100	180	17	3,060	103
1988	300	5,100	180	17	3,060	103
1989	225	4,250	150	17	2,550	103
1990	200	3,400	150	17	2,550	82
1991	309	5,253	210	17	3,570	103
1992	219	4,380	131	20	2,620	160
1993	200	4,000	120	20	2,400	160
Total	2,348	44,290	1,479		27,540	

PARTICIPATION RATES

Participants are defined as multifamily buildings that have had installations performed under CEE's Work Completion and Implementation Process. Historically, about a third of the audited properties have elected not to move to the program's installation stage either because the building owners decided after an audit to recruit or use their own contractors to perform the installation or decided not to do an installation at all. To date, 2,348 audits have been performed with 309, the highest annual level, achieved in 1991. Overall the program has resulted in retrofits in 1,479 buildings and approximately 27,540 units in the Minneapolis area.

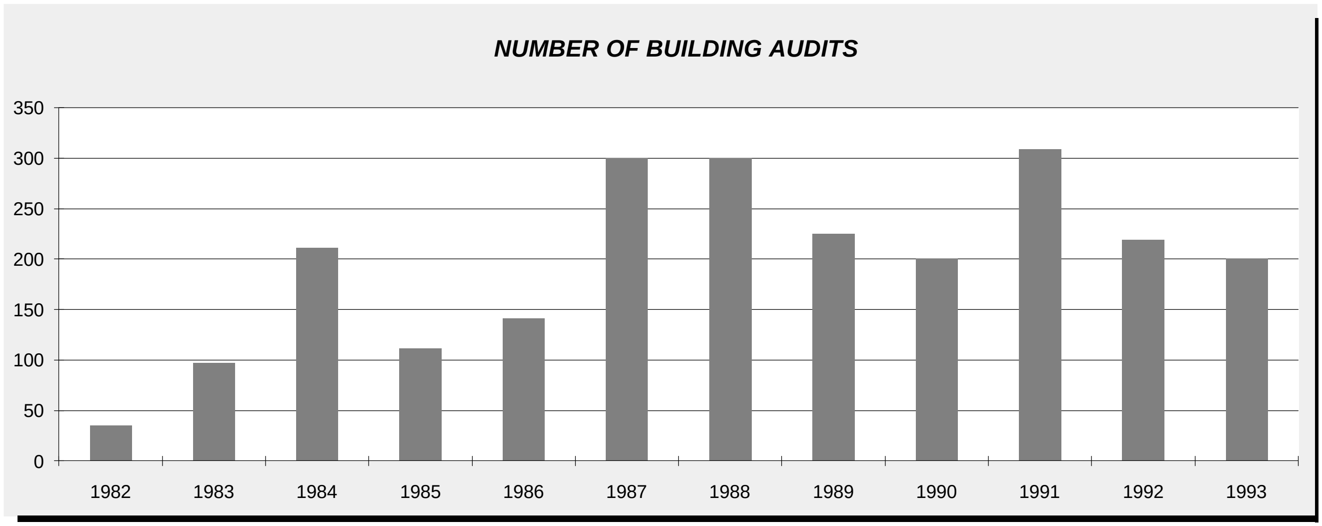
Participation, or what program managers call the "completion rate," whereby recommendations from the audit are indeed installed, has decreased in recent years as the program has saturated the market. Historically the program had realized a 67% completion rate but more recently this has dropped to about 30%.[R#22]

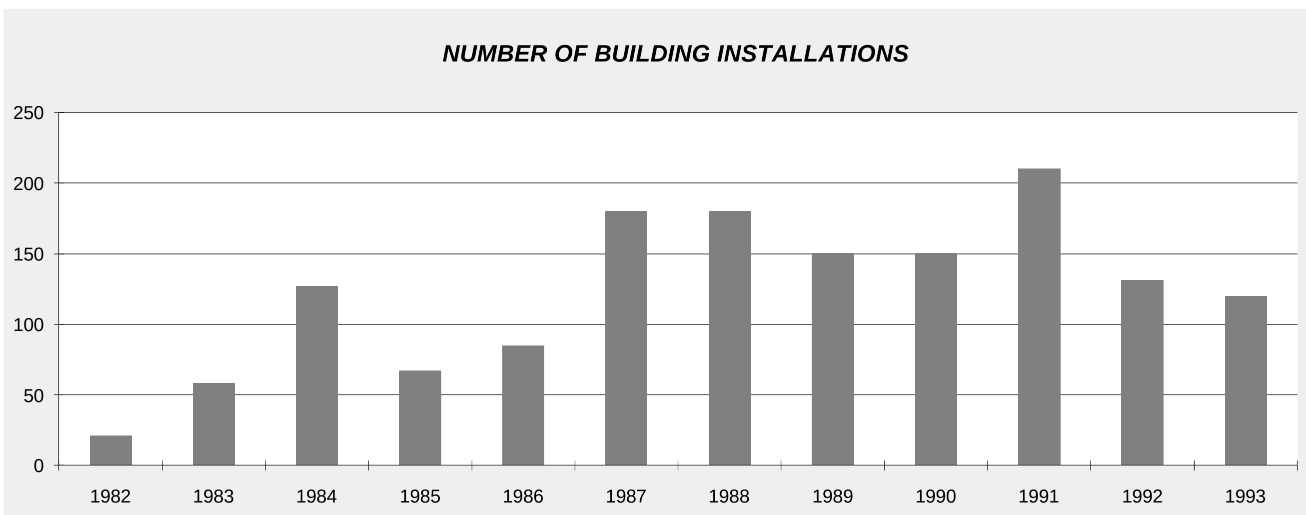
FREE RIDERSHIP

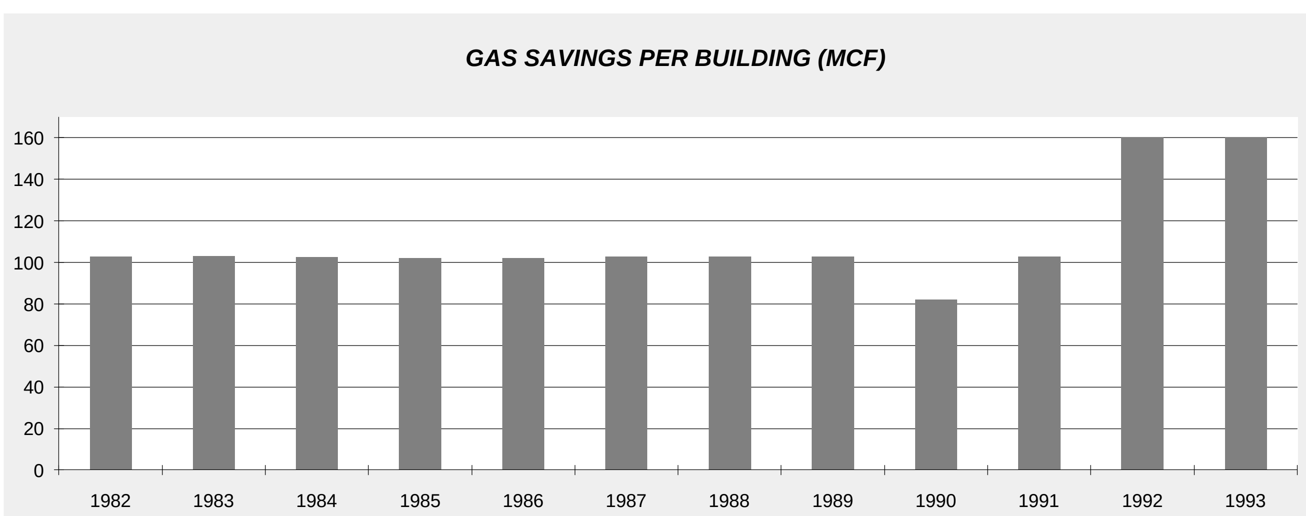
Free ridership has not been found to be a significant problem with the program because energy efficiency is a low priority for most multifamily building owners. They are generally unaware of the potentials in performing retrofits and are uninterested in making energy improvements. The CEE/Minnegasco approach, however, makes it so easy for the owner to make the improvements that they do tend to make the improvements after an audit.

MEASURE LIFETIME

Each strategy involved in retrofitting a multifamily building involves varying and sometimes multiple measures installed. A conversion boiler tune-up has an average measure life of eight years, steam balancing of a single pipe system (10 years), vent dampers (10 years), steam to hot water conversion (25 years), reset and cut-out controls (10 years), energy cost allocation (10 years), front end modular boilers (15 years), condensing heaters (10 years), recirculation loop controls (5 years), and integral flue dampers (10 years). The Results Center and CEE have estimated average weighted measure life for all the measures combined to be 11 years.[R#5] ■


NUMBER OF BUILDING AUDITS
350
300
250
200
150
100
50
0
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993


NUMBER OF BUILDING INSTALLATIONS
250
200
150
100
50
0
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993


GAS SAVINGS PER BUILDING (MCF)
160
140
120
100
80
60
40
20
0
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993

Cost of the Program

Minnegasco has paid CEE based on the number of buildings addressed by the program. So far Minnegasco has invested a total of $768,647 to implement the Multifamily Retrofit program between 1987 and 1993, or approximately $475 per building audit. Total program expenditures have ranged from a high of $153,889 in 1987 to a low of $79,600 in 1990. The total program cost in 1993 was $96,323.[R#19]

COST EFFECTIVENESS

The Results Center calculations of cost of saved energy based on total annual costs and lifecycle gas savings are shown in the accompanying table, calculated at various discount rates ranging from 3-9%. This table presents results in cents per hundred cubic feet of gas (¢/CCF) saved. From 1987 to 1993 costs have been consistently under 7¢/CCF except for the program's first year of implementation when in 1987 this cost of saved energy ranged from 7¢/CCF to 10.3¢/CCF. In 1993, the cost ranged from 4.2¢/CCF to 6.2¢/CCF depending upon discount rate used. At a 5% discount rate, the cost of saved energy for the program for all years combined has been 4.5¢/CCF.

Minnegasco is required to screen the program for cost effectiveness using four tests with the Societal Cost Test representing the pivotal test as required by the Minnesota Department of Public Service. To date the Multifamily Retrofit program has been a stand-alone program and has been cost effective, essentially its benefits (gas savings) have exceeded its costs. With a declining completion rate, however, the program's cost effectiveness is challenged and thus its Minnegasco program managers have proposed to fundamentally revise the program design. In fact, if approved by its regulators, the stand-alone Multifamily Retrofit program will no longer exist. Its functions, however, will still be available to customers.

Minnegasco has proposed to continue the audit and post-installation inspection aspects of the program, and to allow customers to proceed with retrofits supported by Minnegasco rebates either independently or using CEE's services. This change reflects Minnegasco's commitment to educating its customers through audits and consultations – which are not required to pass the same cost effectiveness criteria as incentive programs – and serving them with post-installation inspections if warranted. By doing so, the program's services will become "unbundled" and thus cost effective.[R#22]

COST PER PARTICIPANT

Minnegasco pays CEE a total of approximately $475 for each audit performed, but not all audits lead to retrofits. The building owner cost varies with what types of retrofits are installed in their building. Since customer cost is not a reporting requirement to the Minnesota Department of Public Service, these costs are not explicitly documented. CEE does enter approximate values in its program database, but is not confident that these values represent actual costs because of change orders and changed plans. Since the costs are not reported, little effort is made to verify the numbers after the retrofit installations.

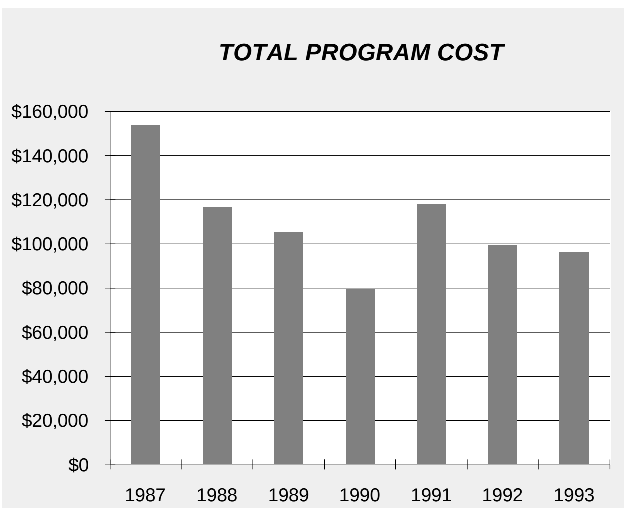
CEE staff, however, market the program to building owners whose number one question is, "How much will my participation cost?" Staff experience has shown that customer costs are typically in the $1,000-1,200/building range, a sum that most building owners draw from their capital budgets. Approximately 30% of building owners take advantage of CEE financing through The Energy Bank that it administers for the Minnesota Housing Finance Agency and using petroleum overcharge funds provided by the Minnesota Department of Public Service. (The Energy Bank is administered by two full-time equivalent staff at CEE and is used more extensively for other residential programs.)[R#11]

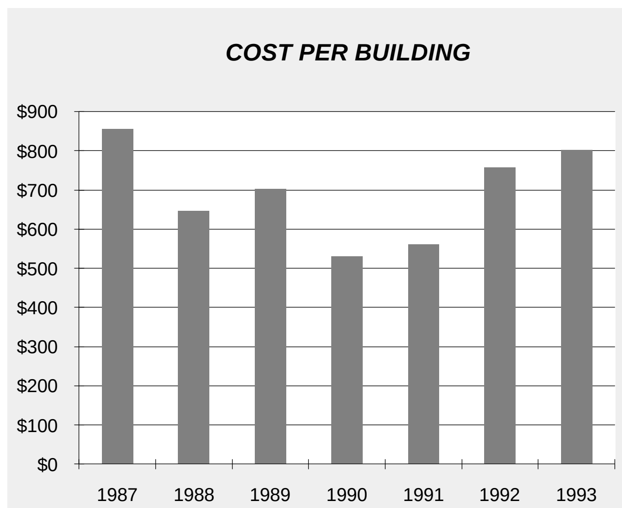
Costs for each specific measure are presented earlier within the discussions of specific retrofit opportunities analyzed by CEE with the support of Minnegasco. In most cases, however, low-cost measures such as resets, cut-outs, vent dampers, low-flow showerheads, and exit lighting are implemented, keeping customer cost low and payback periods short.

COST COMPONENTS

Minnegasco pays $475 for each audit performed regardless of the uptake of the recommended measures. This cost covers the audit as well as other services provided including post installation inspections. This "audit cost" is broken down into several components including administrative, delivery and audit, marketing, equipment, and contracted services. The largest portion of expenditures for the program is for delivery and audit. From 1987 to 1993 this has cost $620,298, or 81% of total expenditures including paying for auditing, scheduling, data entry, and CEE staff salaries. Expenditures for marketing, $48,425, account for 6.3% of total expenditures. Marketing consists of printing (2.2%), seminars (1%), advertising (1.5%), and mailing (1.6%). Administrative costs account for $38,432 or 5% of total expenditures while contracted services are 2.4%, and equipment and supplies require 1.3% of the total program budget.[R#19] ■

COSTS OVERVIEW	ADMIN.	DELIVERY/ AUDITS	MKTG.	SUPPLIES	CONTRACT SERVICES	TOTAL PROGRAM COSTS	COST PER BUILDING
1987	$7,694	$124,188	$9,695	$2,001	$3,693	$153,889	$855
1988	$5,824	$94,001	$7,338	$1,514	$2,796	$116,482	$647
1989	$5,263	$84,937	$6,631	$1,368	$2,526	$105,250	$702
1990	$3,980	$64,237	$5,015	$1,035	$1,910	$79,600	$531
1991	$5,890	$95,070	$7,422	$1,531	$2,827	$117,807	$561
1992	$4,965	$80,132	$6,256	$1,291	$2,383	$99,296	$758
1993	$4,816	$77,733	$6,068	$1,252	$2,312	$96,323	$803
Total	$38,432	$620,298	$48,425	$9,992	$18,448	$768,647	





COST OF SAVED ENERGY AT VARIOUS DISCOUNT RATES (¢/CCF)	3%	4%	5%	6%	7%	8%	9%
1987	6.97	7.49	8.02	8.57	9.14	9.73	10.33
1988	5.28	5.67	6.07	6.49	6.92	7.36	7.82
1989	5.72	6.14	6.58	7.03	7.50	7.98	8.48
1990	5.41	5.81	6.22	6.65	7.09	7.55	8.01
1991	4.58	4.91	5.26	5.62	6.00	6.38	6.78
1992	3.97	4.26	4.56	4.88	5.20	5.53	5.88
1993	4.20	4.51	4.83	5.17	5.51	5.86	6.22
Total	3.95	4.24	4.54	4.85	5.17	5.51	5.85

LESSONS LEARNED

Overall, the program has been highly successful: To date CEE and Minnegasco are pleased with the performance of the Multifamily Retrofit program. Data generated through CEE's research and field tests have been used as the basis for comprehensive demand-side management programs serving the multifamily sector. The program's focus on steam balancing, tune-ups, and vent dampers for steam buildings, and on resets, cutouts, and vent dampers for hydronic buildings has resulted in nearly 30,000 units having been retrofitted in the Minneapolis area. Additionally, low-flow showerheads, efficient common area lighting, and similar measures are addressed in all buildings where appropriate providing additional savings and customer services.

Solid research and demonstration of retrofit opportunities have been key to program success: Research findings have been extremely helpful in motivating building owners to invest in cost-effective retrofits for their buildings. Minnegasco is to be credited for having the foresight to fund CEE's research and testing efforts. However, CEE has found that confirmed energy savings, while necessary for the design and credibility of programs, are only one piece of the DSM puzzle.[R#5]

Working with trade allies has also been important: A comprehensive program must provide additional services to assure that the appropriate retrofits are actually installed and that they are installed correctly. This includes working effectively with trade allies (e.g., suppliers and contractors) to actively introduce and promote new technologies into the marketplace.

Contractor training is essential to proper retrofits: CEE's experience has also shown that contractors need assistance and training in the technical aspects of completing retrofits properly, both for unusual or innovative technologies (e.g. steam to hot water conversion, front-end modular boilers) and for more common measures such as boiler tune-ups, resets, and modular boiler installations.

Reducing building owners' transaction costs supports the process: In addition, building owners need a convenient, one-stop service that not only identifies the appropriate retrofits, but also makes the installation of those retrofits as easy for them as possible. This includes the specification of particular equipment, easy to use financing, the use of pre-screened and trained contractors, and a post-installation inspection process that assures quality control for the building owner.[R#5]

Surprisingly, financial incentives seem to be less important than heightened customer services: In a market which is largely driven by first-cost, an effective program usually needs to include adequate financial incentives (e.g. rebates, zero interest loans, etc.) to assure a high rate of installation in a market. However, CEE has found that financial incentives do not always need to be large, and in the Multifamily Retrofit program no incentive was needed. Through CEE's Multifamily program, using this comprehensive one-stop approach with no incentives and limited financing, they have audited over 900 buildings in seven years, 40% of which have implemented measures through the program and an additional 30% of which have implemented the measures using CEE's information and their own contractors. For some retrofits, CEE's extensive work with multifamily owners has so transformed the market that it is difficult today to find metropolitan area buildings where they have not been implemented. This research from CEE field tests has also been used as a basis for gas utility DSM programs in Wisconsin and other states.[R#5]

Systematic exploration of retrofit opportunities for multifamily buildings has enabled CEE to develop a sound program based on actual measured performance, which delivers real benefits to property owners and utility program goals. The research has debunked some popular favorites and supported others. Through long-term efforts CEE also has contributed 25% of the data in the U.S. Department of Energy's database of multifamily retrofit research.[R#5]

As market saturation has occurred, program design changes are necessary to maintain cost effectiveness: Minnegasco has found the Multifamily Retrofit program to be cost effective for many years, but as the program's completion rate has declined, so has its cost effectiveness. To overcome this problem, Minnegasco has proposed to its regulators that the program's auditing function be split from its installation function. By doing so, Minnegasco can continue to provide the program's services despite the saturation of the market which has threatened the overall program's cost effectiveness.

Audits are essentially an educational tool which may or may not result in any explicit savings. Under the proposed program revision, Minnegasco and CEE will continue to provide audits and post-installation inspections. Since these services aren't intended to create specific savings they are not subject to the same benefit/cost tests which rebate and other direct financial incentive programs must pass. Minnegasco has proposed that any multifamily building energy efficiency installations continue to be supported through its proposed C/I rebate programs.

Multifamily buildings are a factory for "mass production" of energy savings: Due to building booms from the 1950s to 1970s, most buildings in the Minneapolis areas are internally very similar. In essence, this has allowed CEE to "mass produce" energy saving retrofits. A standardized audit format is utilized to expedite the process.

The advantage of these internal similarities in buildings is that CEE has most cost effectively and expeditiously produced energy savings in multifamily buildings. Providing energy services in relation to quick payback technologies such as resets, cut-outs, vent dampers, low flow showerheads, and exit lighting has become quite facile. However, more capital intensive projects with longer, five and ten year paybacks are infrequently undertaken.[R#5]

TRANSFERABILITY

As the Multifamily Retrofit program has saturated the Minneapolis market, Minnegasco has proposed to its regulators that the program be expanded to encompass its entire service territory, an area covering about one-third of the State of Minnesota. And with the program modifications planned – providing greater incentives – the program will likely increase participation both in Minneapolis and throughout the service territory.

CEE has also effectively transferred the program to other areas with similar climates and similar housing stocks. For instance, CEE implemented a similar program for Wisconsin Gas using the base of technical analysis developed by Minnegasco. CEE has also implemented a similar program for Northern States Power, both in Minnesota and its service territory in Wisconsin. Transferability in these cases has been relatively straightforward.

CEE and Minnegasco staff believe that the basic program design is sound and transferable, regardless of the similarity or lack of similarity of the housing stock. Rather than focusing on financial incentives, the program fundamentally provides education and an easy way for building owners to participate in retrofits, improving tenant comfort and reducing energy bills. Program features, such as the popular energy cost allocation, provide guidance for other programs regardless of climate.

Finally, utilities seeking to influence multifamily housing will want to consider a variety of end-uses when developing a program. The Multifamily Retrofit program has focused on gas space and water heating systems. Other multifamily programs have other important emphases, such as weatherization and electricity-saving measures. Thus the Multifamily Retrofit program is one means of addressing energy use in this difficult to reach sector, but is an isolated piece that may be effectively coupled with other program emphases for maximum savings. ■

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