Retrocommissioning Programs: Current Efforts and Next Steps

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ABSTRACT

Retrocommissioning is the process of commissioning an existing building. Most large commercial buildings can benefit from retrocommissioning because few buildings are commissioned when new and even those buildings that are commissioned when new frequently get out of tune due to sub-optimal maintenance. Previous studies have found that retrocommissioning can typically reduce energy use by 5-20% with simple paybacks of 1-3 years.

In the last few years, a growing number of utilities and other program operators have recognized the benefits of retrocommissioning and begun to operate pilot programs to promote retrocommissioning to their customers. These include programs operated by Portland General Electric, the Sacramento Municipal Utility District, Boston Edison, Texas A&M, the Minneapolis Center for Energy and the Environment, and the State of Tennessee. This paper introduces the retrocommissioning concept and presents programs and their accomplishments. Specific lessons learned from experiences to date are used to develop recommendations for promoting retrocommissioning, both in the regions that are currently pursuing this energy-saving opportunity and in other regions that have yet to embrace retrocommissioning.

Introduction - Retrocommissioning Opportunities

Most owners are not aware of the sizeable opportunities that are available to them in their existing facilities. As long as a building is reasonably comfortable and operating within the broad band of "normal" parameters, many problems will not be noticed until there is a catastrophic failure or something occurs to make a silent problem visible. Existing building commissioning, also known as retrocommissioning, is an event in the life of a building that systematically investigates for opportunities to improve and optimize a building's operation and maintenance (Haasl and Sharp 1999).

All of the stakeholders in an existing building can benefit from retrocommissioning. Implementing a retrocommissioning process will provide owners the opportunity to identify building operation, control, and maintenance problems that prevent their building from performing optimally and in alignment with how the building is currently used. Owners also can also expect measurable energy savings and reductions in operation and maintenance costs for the building. They will also frequently benefit from improved equipment performance, indoor air quality, worker satisfaction and productivity. Retrocommissioning also can provide owners with complete and accurate documentation of the building's systems. Building occupants can frequently expect a more comfortable, healthy work

environment that in turn reduces the owner's liability exposure due to poor indoor environmental quality and occupant complaints. Building maintenance staff will receive fewer tenant complaints, gain better knowledge and understanding of building systems, and gain the tools needed to implement an ongoing maintenance program that maintains the new level of building performance. Although most retrocommissioning opportunities (and benefits) are invisible to an owner, in most cases, the energy savings alone make retrocommissioning a worthwhile business investment.

The large opportunities from retrocommissioning are illustrated by a 1997 review of field data on 44 commissioning projects on existing buildings. This review found that commissioning existing buildings "often result[s] in whole-building energy savings of 5-15% and paybacks of two years or less." Energy cost savings in these projects ranged from 2-49% with a median of 19%. This information is shown graphically in Figure 1.

Simple payback periods ranged from less than a month to 4.6 years, with a median of 0.6 years (see Figure 2) (Gregerson 1997).

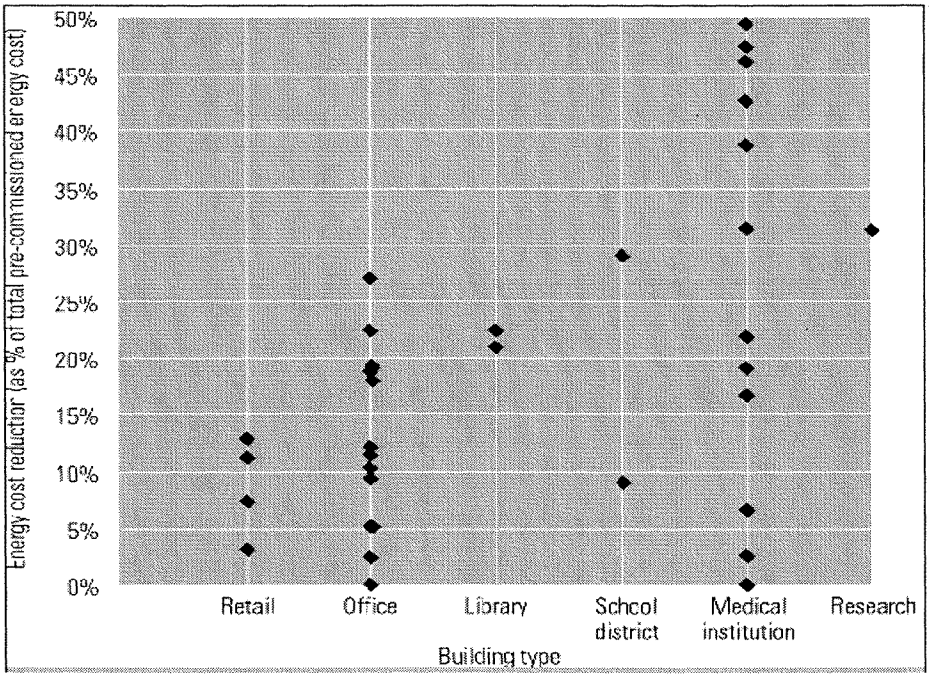

Figure 1. Energy Cost Savings For a Sample of Retrocommissioning Projects. Copyright E-Source, Used With Permission

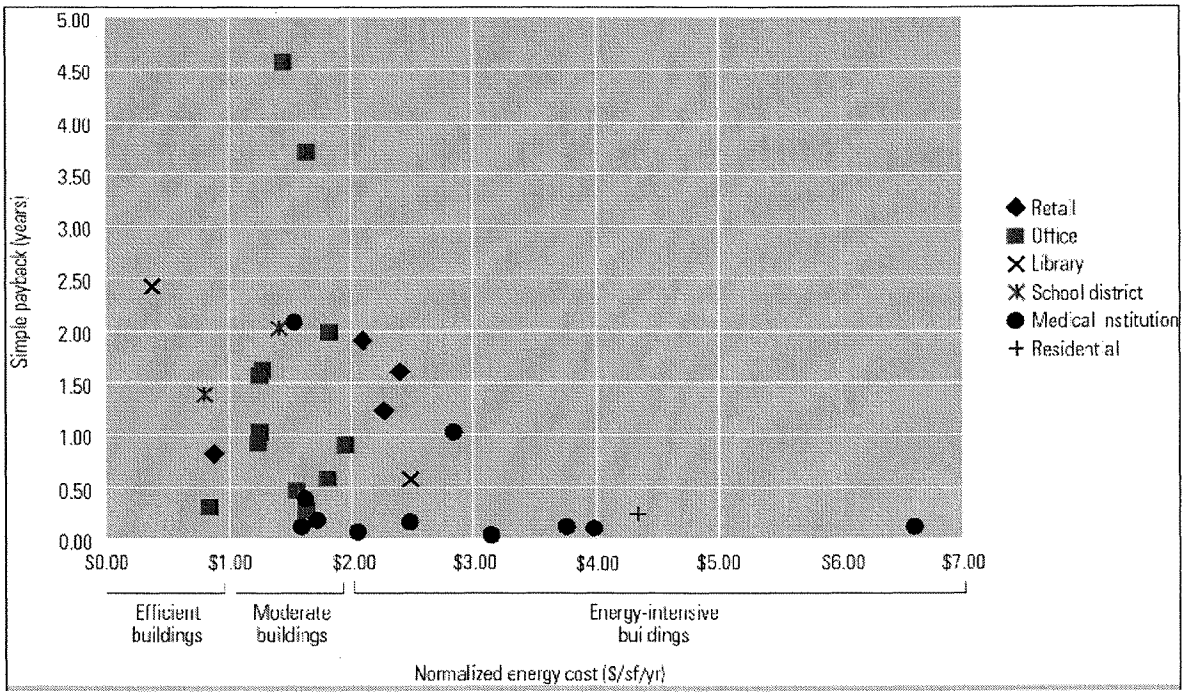

Figure 2. Simple Payback Period For a Sample of Retrocommissioning Projects. Copyright E-Source, Used With Permission

The potential for reducing commercial sector energy use through retrocommissioning is enormous. A 1998 study estimated potential energy savings in the U.S. from retrocommissioning to be approximately 60 billion kWh of electricity and approximately 190 trillion Btu of natural gas by 2010, a reduction of nearly 5% off of projected 2010 U.S. commercial sector energy use. This study assumes retrocommissioning is limited to 85% of buildings at least 25,000 square feet in size. These savings topped the list of the 56 different energy saving technologies and practices in the residential and commercial sectors examined in this study (Suozzo and Nadel 1998).

Barriers to Retrocommissioning

Multiple barriers inhibit the spread of retrocommissioning, including:

- Few owners and managers are familiar with commissioning services and their benefits.
- The value of commissioning services has not been demonstrated enough to satisfy some owners and managers; some perceive that the claims are too good to be true.
- In most organizations, there is not an established budget, procurement vehicle, internal responsibility, management system, contractor relationship, or precedent for procuring retrocommissioning services. Similarly, most contractors lack procedures for defining , managing, marketing, or making a profit from these services.
- Experienced staff and outside service providers that can lead retrocommissioning efforts are in very limited supply.
- Training for building staff in commissioning-related activities is often not readily available.

- Managers often do not know how to locate experienced staff or outside providers nor can they identify which staff and service providers are well qualified to do commissioning work.
- The limited size of the current market for commissioning services makes many potential service providers reluctant to get the training and experience necessary to enter the business.
- Lack of time, short-planning horizons, and institutional inertia makes it difficult for owners and managers to consider new approaches.
- Internal accounting practices, such as the separation of energy, maintenance, and capital budgets makes it difficult to obtain funds for new services or to provide direct financial benefits to those who agree to finance these services out of their budget (Nadel, Hinge, and Gordon 1999).

In addition to the above barriers, government building managers face some additional barriers: restrictive hiring and procurement practices; the presence of too many decision-makers; limited manager discretion; and highly aggregated metering. Rental properties also face some additional barriers: the high frequency of remodeling (making it easier for buildings to get out of adjustment); the widespread use of third-party managers who do not directly benefit from energy cost reductions; and the fact that energy efficiency is not reflected in standard building valuation formulas (Parker and Chao, 1999).

Approaches to Retrocommissioning

Owner Strategies

Owners have several strategies available to them to capture the sizeable opportunities that exist within their buildings, all of which involve a team effort. Depending on the project scope and the resources available the owner may use:

- A retrocommissioning team model that consists of an outside commissioning provider working with member(s) of the building operating staff and technical specialists.
- A comprehensive energy manager model that consists of facility managers and one or more building operators trained in how to look at building systems from an integrated operating perspective.
- A continuous commissioning team model that is similar to the retrocommissioning model with the addition of continuous long-term monitoring by trained commissioning engineers.

Under the retrocommissioning model the provider works closely with building staff to develop the knowledge base needed for a comprehensive retrocommissioning project. The provider's experience and investigations in similar settings results in the discovery of many hidden problems that when corrected, can yield large energy savings more than justifying their expense. Involving the building staff as part of the process is a key strategy for maintaining energy savings after retrocommissioning. A building operator armed with the training and experience gained during the retrocommissioning process will be better able to evaluate changes in building performance over time.

Building Operator Certification (BOC)

A professional development program for building operators, BOC demonstrates competence in the full range of skills needed to maintain building systems at their optimum performance. Since 1995, the Northwest Energy Efficiency Council (NEEC) has certified over 450 operators in the Northwest with an additional 700 currently in the program (The Alliance, 2000). Beginning in 2000, the Northeast Energy Partnership (NEEP) will offer BOC in New York, New Jersey and New England.

Highly trained building operators can perform many of the activities that are required of a commissioning provider. They know their facility intimately, and with proper training can learn how to identify and analyze problems in specific building systems and coordinate efforts to make changes to the systems. While in most cases they will not have the testing/balancing and design engineering background that is typically required in a retrocommissioning project, they are in the best position to manage an ongoing program that will maintain the retrocommissioning results.

The continuous commissioning model, similar to the retrocommissioning model, relies on an outside commissioning provider to identify and fix HVAC and comfort problems in the building. Again, building maintenance and energy managers are critical team members who work directly with the provider as the problems are uncovered and remedied. In this model, when the commissioning is complete, the team continues to work together to monitor and analyze building performance data from permanently installed metering equipment.

Utility Strategies

Electric and gas utilities have operated energy efficiency programs for nearly two decades. Many of these utilities continue to operate programs today. However, in some states (New York, Vermont and Wisconsin) program administration has been taken over by state agencies as part of electric utility restructuring. In this paper we use the term utility for convenience, but include both utility- and state-operated programs that are financed through utility bills.

Utilities have many rationales for operating energy-efficiency programs, but today, three paradigms tend to dominate: market transformation, resource acquisition, and customer service. Market transformation initiatives seek to remove market barriers that impede specific energy saving practices, and over time, make these practices common and self-sustaining. As discussed below, several utility programs approach retrocommissioning from a market transformation perspective and develop strategies for removing the market barriers to retrocommissioning. The market transformation approach to program design is discussed extensively in many papers (for example, see Nadel and Latham 1998).

Resource acquisition programs traditionally seek to reduce energy use whenever conservation is less expensive per kWh than available electricity supplies. In recent years this term is commonly used to indicate the direct and quick acquisition (relative to market transformation) of energy savings in order to reduce power plant emissions, help address power reliability problems, and defer the need for expensive (and sometimes controversial)

upgrades to the distribution system. Due to the large and cost-effective savings it generates, retrocommissioning is an effective resource acquisition strategy.

Customer service has been a goal of most utilities for a long time. In recent years, with the onset of competition due to restructuring, some utilities have begun to use retrocommissioning as part of their efforts to provide valued-added services to customers. These services can be provided by traditional utilities, or they can be provided by competing power retailers as part of their efforts to retain or build market share. Frequently these services are provided on a matching cost basis, although they can also be offered on a full cost-for-service basis. Several of the programs discussed below have a significant customer service focus.

These paradigms are not competing, but can often complement each other. For example, customer service is frequently a part of market transformation and resource acquisition focused programs. And with retrocommissioning, it is even possible to combine a market transformation and resource acquisition focus by conducting short-term resource acquisition in ways that have direct and long-term impacts on market barriers.

In the next section, we discuss many of the utility retrocommissioning programs that are currently underway. Summary data for each of these programs are provided in Table 1.

Programs &Activities

Boston Edison

Program Description and Key Features. Boston Edison began a pilot retrocommissioning program in 1998. The long-term goal of this program is market transformation. Boston Edison's program is designed to help establish an infrastructure of skilled local retrocommissioning service providers (including both consultants and skilled in-house staff) and to also educate building owners on the value of these services. The theory is that once owners are aware of the benefits of retrocommissioning and once skilled local staff and service providers are readily available, then the substantial benefits of retrocommissioning will help practitioners successfully market to building owners and further utility intervention will not be needed (Boston Edison, 1998).

In the fall of 1998, Boston Edison worked with a large customer, Raytheon, to retrocommission one of its facilities. In 1999, Boston Edison conducted an evaluation of the Raytheon project and undertook planning for several additional projects including a training course on retrocommissioning for skilled facility managers, and several other consultant-led retrocommissioning pilots. This training course and the additional pilot projects are scheduled for implementation in 2000 and 2001 (Brown 2000).

Program Results & Lessons Learned. The retrocommissioning demonstration project on three buildings (total 230,000 square feet) at the Raytheon campus in Sudbury, Massachusetts resulted in 34 recommendations. The project was revisited in February 1999 to assess the customer's response to the process and the impact of the findings on implementation (Thorson, 2000). Of the initial 34 recommendations, ten low-cost findings had been implemented and two low-cost findings were in the process of being implemented by staff. Eleven capital-intensive findings had been scheduled for evaluation and possible

funding by an energy service company in the near future. Eleven more findings were determined not to be feasible for implementation.

The estimated annual cost savings from the 12 low-cost measures came to $151,542 at a project implementation cost of $2,000 (Table 1). These savings account for 22 percent of annual energy use. The estimated annual level of savings achieved to date is $121,234, or 80 percent of the calculated potential energy savings. Verification using utility bill data, normalized for weather, substantiates these figures. The facility is still in the process of implementing measures which when finished are expected to meet or exceed the calculated potential cost savings. Due to the in-house capability of the staff, this project has resulted in a net positive cash flow to the owner in less than one year of over $100,000 per year.

Participants identified several lessons from the pilot including:

- Potential energy savings, availability of funding and in-house staff participation were the major factors impacting implementation.
- A gap in utility offerings was identified – lack of financing or incentives to assist the building owner in implementing findings in the less-than-two-year payback range.
- This project was largely successful thanks to a highly motivated utility program manager who recruited the customer and helped the project to progress smoothly, and a committed customer who actively participated in the retrocommissioning process and implemented many recommendations.

Since the Raytheon pilot, the overall Boston Edison program has progressed slowly due to the departure of the original utility manager and the fact that other utility staff are not able to devote much time to the program.

Table 1. Summary of Retrocommissioning Program Results

Program (start)	Sites	Ft^2 (ooo)	Costs Cx Study	Costs Cx Imp.	Savings kWh / yr	Savings kW / yr	Savings Therms / yr	Total Savings $	Payback yrs	$Cost/Ft^2$
BECO (1999)[1]	1	230	$35,000	$2,000	1,876,284		13,965	$151,542	0.2	$0.16
PGE (1998)	5	1,658		$201,227[2]	5,426,610		119,000	$276,564	0.7	$0.17
SMUD (1999)	4	895	$114,000	$58,533	2,130,154		91,617	$160,926	1.1	$0.19
Com Ed (1998)	11[3]	12,135	$134,135	$149,564	1,637,360	840		$112,323	2.5	$0.16[4]
CEE (1999)	4	946	$149,044	$343,350				[5]		$0.52
NEEA (1998)[6]	17	1,216	$280,840							
Texas A&M (1996)[7]	34	4500[8]		$2.5M[9]	15,500,000	18,000	3.1M[10]	$10M	0.9	$0.56
TN (1996)	1	175	$50,000	$60,000				$60,000	1.8	$0.63

[1] Phase 1-Non capital improvement measures only

[2] Total study and implementation costs including PGE oversight

[3] Two sites did not meet program criteria, an additional site implemented measures but did not show savings, and a further site chose not to implement measures

[4] Average cost/ft^2 on projects that were implemented

[5] Total savings have not been calculated on all measures

[6] Studies and implementation have not been completed

[7] Only projects on Texas A&M campus included

[8] Square footage of sites where continuous commissioning was implemented

[9] Total costs for continuous commissioning process and metering/monitoring of non-continuous commissioned buildings on campus

[10] Hot water therms savings only-An additional 250,000 MMBTU of chilled water savings were also achieved

Portland General Electric

Program Description and Key Features. Portland General Electric's existing building commissioning program is designed to identify O&M and minor capitol improvements in commercial and industrial facilities. Major retrofit projects are not eligible for the program. First year (1999) program marketing targeted 100,000+ square foot buildings with direct digital controls, high electrical consumption, good mechanical equipment, and in-house operational staff.

The program goal is to meet the Utility Program Cost and Total Resource Cost targets established for other demand-side management programs, with a real levelized cost not to exceed $0.02 per estimated kWh saved over the life of the project. The program provides financial incentives to have a local commissioning authority perform an initial scoping study and then to fund or co-fund implementation of project recommendations. Project funding is conditional on the customer implementing O&M projects with paybacks of two years or less. The utility prefers that the customer selects and contracts directly with a commissioning authority. A portion of the contractor's scope also includes determining actual savings achieved that are later verified by Portland General Electric (Peterson & Findlay 1999).

Program Results and Lessons Learned. One commercial and four industrial HVAC projects were completed during the first year of the program. Total savings were estimated at 5,426,610 kWh. Maintenance staff in the industrial campus environments knew where to look for problems but needed the technical resource assistance this program provided. The commercial facilities typically had knowledgeable maintenance staff but used this program to overcome expense and implementation hurdles posed by skeptical owners. The utility is very encouraged by these results because all of the projects were located in the private sector where traditionally it has been very difficult to implement retrocommissioning. To date, four additional projects have signed up for the program in 2000 (Peterson 2000).

Sacramento Municipal Utility District (SMUD)

Program Description and Key Features. SMUD initiated a pilot retrocommissioning program in May 1999. The goals of the program are to (1) promote market transformation in the retrocommissioning arena and (2) reduce overall building energy consumption through low-cost/no-cost operational improvements. SMUD selected two non-local contractors to apply their own commissioning methodologies at two sites each. The four buildings selected for participation covered a wide range of building types, occupancy and energy intensity. Based on an evaluation of the results of the pilot projects, SMUD plans to fine-tune the commissioning requirements for future projects and decide whether to expand, maintain or eliminate the program (Parks 2000).

Program Results and Lessons Learned. Investigation into the four diverse commercial and institutional buildings identified opportunities to reduce energy use by 2.3 percent to 13.2 percent from low-cost or no-cost improvement measures. A number of the recommendations involved simple adjustments to equipment and control strategies and were performed during the site investigation or shortly thereafter. Most of the other

recommendations have paybacks of well under one year and are planned for implementation in the near future (2000). SMUD's Measurement and Evaluation Group is tracking implementation of these improvements and plans to assess actual savings. Facility staff participating in the projects were quite satisfied with the experience and findings. However, SMUD recognizes that to promote market transformation on a larger scale, a future program will need to expand education and outreach activities to a broader audience (Parks 2000).

Commonwealth Edison

Program Description and Key Features. The Maintenance, Operations and Repairs (MORES) project was a two-year program by Commonwealth Edison (Com Ed) to introduce retrocommissioning to its customers. The goal was to reduce peak loads primarily by identifying and offering simple low cost or no-cost cooling system improvements. The utility collaborated with trade allies (i.e., commissioning providers) to target a wide variety of buildings with electric chillers and minimum load profiles of 1000 kW. Building types included hospitals, offices, university facilities, and retail establishments. The project consisted of two phases; a study phase where the commissioning provider would diagnosis problems, recommend "spot" improvements and write a detailed study, and an implementation phase where the improvements were carried out. Each study was reviewed by Com Ed to select measures for implementation that met kW reduction and cost goals, and could be implemented by the 1999 summer cooling season. To encourage participation, Com Ed matched building owner funds up to $8,000 for the study costs and up to $10,000 for implementation costs (Kessler et al. 1999).

Program Results & Lessons Learned. Anecdotal evidence suggested that smaller facilities with less management bureaucracy had a higher rate of implementing all project recommendations. Larger facilities were more inclined to rectify only problems that had immediate benefits. Eleven buildings with almost 12 million square feet were surveyed and most received implementation incentives under the program guidelines. kWh savings are based on energy study projections. kW savings are based on what Com Ed paid to participating customers after the technical review process was completed. After implementation, savings were verified using spot utility bill analysis and customer interviews (Philbrick 2000). The utility saw this program as low cost demand reduction - $132/ saved kW versus $300/kW of peaking gas-fired generation (Kessler et al. 1999).

Northwest Energy Efficiency Alliance: Commissioning of Public Buildings

Program Description and Key Features. In 1998 the Northwest Energy Efficiency Alliance (The Alliance) funded a multi-year commissioning market transformation program that targets public facilities in Oregon, Washington, Idaho, and Montana. The overall program goal is to establish a market for new construction building commissioning and retrocommissioning services in the Northwest. To achieve this goal, each state has developed its own program design with the following key features in common: demonstration projects with technical assistance to owners, development of technical and marketing information, case studies that include costs and benefits, drafting of a model public policy for commissioning, and support for developing the commissioning services

infrastructure. While the program focus was initially on new construction commissioning, Oregon, Washington and Montana have included retrocommissioning projects in their portfolio of demonstration projects. Depending on their program design, each state is offering various services to the participating owners. At the conclusion of the Alliance program, a body of case studies describing processes and results will be produced for use throughout the region. (OOE,1997)

Program Results & Lessons Learned. After two years, the Alliance's project has seen mixed results. The project helped launch the establishment of the Building Commissioning Association (BCA). This organization will help develop consistent standards for building commissioning providers throughout the country. 19 retrocommissioning projects and 17 new construction commissioning projects have begun and awareness is increasing in the targeted groups. Some of the primary barriers identified during the investigation phase still exist. The commissioning concept is not fully understood and many decision makers still maintain confidence in the traditional construction processes and O&M practices. Short term financial planning (lowest first cost/square foot) continues to take precedence over lifecycle cost analysis and higher quality building construction. The largest challenge is maintaining the momentum over the long time periods required to complete projects and achieving "real" transformation of State policies (Jennings, Harris, and Pekalski 2000).

Minneapolis Center for Energy and the Environment

Program Description and Key Features. As part of Rebuild America's "Competitive Buildings Initiative", the Center for Energy and the Environment (CEE) is forming partnerships with institutional, commercial, and multi-family building owners. These partnerships are designed to identify buildings' with energy-saving potential, analyze the energy systems, and provide unbiased recommendations on improvement strategies. Retrocommissioning is one of the services CEE is offering to its partners. CEE is also working to integrate these partnerships with local electric and gas utility efforts.

In 1998, CEE worked with the Eden Prairie School District and the Fairview Medical Center. In Eden Prairie, Forest Hills Elementary and Central Middle schools included a retrocommissioning component as part of a comprehensive plan for upgrading the HVAC system's indoor air quality (IAQ) standards. The CEE analyzed each school's HVAC equipment, and controls, and helped develop a commissioning plan. At Fairview Medical Center, CEE analyzed the Riverside North (40,000 sf) and the University of Minnesota Unit J sites. The intention of these two medical center projects was to find enough energy savings to pay for the commissioning services.

Depending on the type of facility and its mechanical systems, one of two different methods of retrocommissioning and savings verification were used. The two school projects used the traditional retrocommissioning model. CEE contracted with PECI to design a model commissioning plan and then retrocommission the HVAC and control system in one of the schools. CEE worked directly with the school district on the second demonstration.

At the University of Minnesota Unit J medical facility, CEE chose to implement the continuous commissioning model. Additional sub-meters were installed to track specific buildings and equipment energy usage. CEE contracted the services of the Energy Systems

Laboratory of Texas A&M University to develop and implement a continuous commissioning program in cooperation with the facility maintenance staff.

Program Results & Lessons Learned. The Eden Prairie project goal was to increase indoor airflow to 15 CFM per student. As part of the air rebalance and commissioning investigation, fire damper, temperature stratification, and night setback control sequencing problems were identified and corrected. At the Fairview Medical Center's two sites, temperature and pressure sensors were out of calibration, chillers were not being controlled by the facility's energy management system, damper actuators were not functioning correctly, and excessive outside air was increasing energy usage. The problems were fixed and the resulting energy savings easily paid for the retrocommissioning and continuous commissioning services. After retrocommissioning was successfully demonstrated at Riverside North, CEE found it easier to convince the facility staff at Unit J that continuous commissioning could benefit them and would not be a threat to their jobs (Szydlowski 2000).

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State of Tennessee Action Plan

Program Description and Key Features. In 1996, the State of Tennessee participated in a DOE/EPA funded demonstration project to tune-up the Citizen's Plaza office building in downtown Nashville, Tennessee (Haasl 1996). The State's Department of General Services continued to investigate the value of retrocommissioning as part of their statewide energy strategy by hiring an outside firm to retrocommission the 175,000 sf Chattanooga State Office Building (Edmunds 1997). The State's objectives were to obtain cost effective savings, identify and recommend operation and maintenance procedural changes, identify HVAC health and safety items, and use this experience to develop a statewide retrocommissioning program. In addition, the Tennessee Valley Authority used the Chattanooga project to test new short-term diagnostic evaluation tools. Midway through the project, the State decided to replace the existing energy management control system.

Program Results & Lessons Learned. With the decision to install a new energy management control system, the retrocommissioning scope was expanded to include commissioning the new equipment. The Chattanooga project yielded 45 HVAC, controls, documentation, and O&M improvements. Annual energy savings from the retrocommissioning were estimated at $61,000. The total cost of the project, including the commissioning of both the existing building systems and the new EMCS, totaled approximately $110,000. This results in a simple payback of 20 months or less than two years for both the retrocommissioning and new equipment. The excellent results and experience gained from this project helped in forming one segment of the state's comprehensive State Building Energy Management Program (Edmunds 2000).

Texas A & M Continuous Commissioning

Program Description and Key Features. The continuous commissioning process developed in 1993 by the Energy Systems Laboratory at Texas A&M University has been reported on extensively elsewhere (Liu et al.1997 and 1997; Claridge et al, 1996). As of 1998, the measured savings resulting from continuous commissioning projects had reached

$13,980,000. Recognized as an attractive energy conservation measure, the goals of the continuous commissioning process are to optimize the operation of existing systems, improve comfort, solve IAQ problems, minimize energy retrofit costs, and guarantee continuous optimal performance in future years. Continous commissioning tends to work most effectively on buildings several hundred thousand square feet and larger.

Like retrocommissioning, continuous commissioning is a systematic way of identifying and correcting building system problems and optimizing performance. A key difference is that continuous commissioning rigorously attends to the persistence of energy savings by continuously collecting and analyzing energy use data via permanently installed metering equipment. When changes are noted in building operations either from ongoing collection of monitored data or from facility operators themselves, the engineers will revisit the facility to determine what is causing the problems. The commissioning engineers and facility staff then work together to fix the problems.

Program Results and Lessons Learned. The program has consistently produced energy savings equivalent to traditional audit/retrofit types of projects (e.g. savings of 20%) at one third of the cost. Project effectiveness is very dependent on a high level of support from the facility administration. Continuous commissioning must be part of an institution's long-term strategic plan (Liu 1999). The maintenance staff must be able to work with the facility engineers to learn how to incorporate this energy management methodology into their daily routines. For continuous commissioning to be cost effective, the educated maintenance staff must eventually be weaned from constantly using the outside consulting engineers for minor adjustments. The Energy Systems Laboratory is continuing to update its training processes to find better methods to cost-effectively train maintenance staff (Claridge, 2000).

Key Success Factors: Making Retrocommissioning Common Practice

Whether the overall business strategy is that of resource acquisition, market transformation and/or customer service, the programs described in this paper share several key success factors important to making retrocommissioning of commercial buildings common practice. These include:

Education of owners and building facility staff in the value of commissioning

- Estimating the potential savings benefits and costs for implementation is an important part of the commissioning provider's interim and final reports that the customer uses to determine which measures are implemented.
- All programs recognize the need to include and work with committed building facilities staff. Early in the process, their direct involvement identifies for the commissioning provider existing building performance problems. Their participation throughout helps to ensure acceptance of changes to building systems and the ongoing persistence of savings.

Energy focus coupled with identifying comfort, system control and IAQ problems

- Most programs recognize that the benefits of commissioning existing buildings extend well beyond immediate energy savings to such benefits as extended equipment life, improved indoor air quality, improved worker productivity, and reduced O&M costs. However, none of the programs has in place systems for tracking these benefits.

Formalized processes using interview, observation and manual diagnostics to collect building data and analyze performance issues

- The commissioning provider's toolkit typically includes both familiar and readily available performance data acquisition methodologies as well as more sophisticated processes where available. While the current focus is on large, complex buildings, campuses and facilities where more sophisticated and expensive diagnostics is practicable, there will be numerous opportunities for different levels of retrocommissioning rigor as the industry develops.

Project assistance and/or financing

- Retrocommissioning has demonstrated opportunities for substantial savings with very short paybacks. However, at this stage of development all programs offer some type of financial assistance to offset the perceived costs and risks. As the process becomes more known and understood, we anticipate there will be increased interest and need to develop more routine types of financing.

Long-term goal of developing well-qualified local providers

- All programs except for two are presently using non-local firms to perform the retrocommissioning demonstrations. The lack of a readily accessible infrastructure for these services is a program limitation recognized by all participants.

Conclusion and Recommended Next Steps

In the past several years, four utilities have started retrocommissioning programs and several other organizations have begun programs that include retrocommissioning activities. Initial results from these programs are quite encouraging. Based on the available information, it appears that these programs are achieving significant savings and are cost-effective to both building owners and sponsoring utilities.

However, all of these programs are small-scale pilot programs; none have attempted broad-scale operation yet. Given the positive results to date, it is probably time to expand some of these programs to serve many more buildings each year, in order to achieve much more substantial energy savings and benefits, and to contribute towards overcoming some of the barriers hindering retrocommissioning and thereby make retrocommissioning common practice. The key focus during ramp up should be building the infrastructure of skilled local service providers and educating customers about the benefits of retrocommissioning so that many owners agree to participate. In addition, program operators need to identify appropriate marketing strategies for different market niches. Incentives to pay a portion of commissioning and implementation costs should continue until the benefits of retrocommissioning are amply demonstrated to building owners. Furthermore, improving retrocommissioning methods and tools could help the process to go more smoothly. These different strategies are discussed in more detail elsewhere (Nadel, Hinge and Gordon 1999).

Retrocommissioning helps meet the needs of building owners and of states and utilities pursuing market transformation, resource acquisition, and customer service strategies. It is time to move from pilot programs to larger-scale promotions so that the many benefits of retrocommissioning can be more widely captured.

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