

# **Not Quite Retrocommissioning – Using Lessons Learned from RCx Programs to Create a Cost Effective Option for DSM Programs**

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## **Abstract**

In the fall of 2009 Franklin Energy Services launched a Retrocommissioning (RCx) Pilot program for Consumers Energy, the largest provider of electric and natural gas service in Michigan. A primary goal of the pilot program was to evaluate the cost effectiveness of an operations and maintenance (O&M) review phase as an additional element or alternative to traditional retrocommissioning. This paper discusses lessons learned during the pilot program and the results of this experimental approach.

## **The Opportunity for RCx**

Existing building commissioning also called retrocommissioning is a quality process used to verify that buildings are operating correctly. The term commissioning comes from ship building. A ship is described as commissioned when it has been performance tested, has had deficiencies corrected, and its crew has been fully trained on proper operation and maintenance.<sup>i</sup> This quality process can and should be applied to commercial buildings given the magnitude of expenditures associated with energy consumption in these facilities, estimated by the Energy Information Administration (EIA) to total close to \$170 billion in the U.S. in 2010.<sup>ii</sup> Commissioning focuses on correcting problems with and optimizing existing systems which leads to lower energy costs and quicker paybacks. Available data on retrocommissioning projects shows actions resulting in an average facility energy savings of 16% with average payback of just over one year.<sup>iii</sup>

There are many barriers to RCx becoming common practice in facilities. RCx is time-intensive, expertise-driven, and focuses on making changes to “business-as-usual” operations and maintenance activities that largely serve to ensure occupant comfort and minimize complaints. Further exacerbating the challenges, many facility teams are understaffed, under budgeted and undertrained. While owners have been reducing staffing and deferring maintenance costs with the hope of lowering their operating costs, the practice has resulted in higher maintenance costs as deferred maintenance shortens equipment life, increased energy consumption and decreased occupant comfort. Many maintenance teams are reporting that they spend the majority of their time in “fire fighting mode” responding to equipment failure and addressing comfort complaints. Since most owners treat energy costs as fixed rather than manageable costs, very few facilities have metrics to track energy performance even fewer facilities tie operator performance evaluations to energy costs.

## **Traditional RCx Process**

Most RCx programs follow standard RCx best practices including 4 phases: planning, investigation, implementation and verification. Planning phase activities include a full evaluation of the facility, determining the facility requirements that will be a metric for testing, and creating functional tests and diagnostic plans that will allow the commissioning team to verify if the facility requirements are being met. Commissioning agents typically spend between three and nine months logging sensor

data, performing functional tests and spot checks to gather all of the analysis data needed during the investigation phase. The primary deliverable of the investigation is a master list of corrective measures needed to address performance issues. During the implementation phase some if not all of the corrective measures are acted upon by the customer, commissioning authority or a contractor. Verification activities are focused on retesting to insure that the measures are actually corrected and verifying energy savings achieved.

## **RCx in DSM programs**

Retrocommissioning has been promoted, developed and implemented primarily through DSM programs as an element in commercial-sector energy efficiency portfolios. The Lawrence Berkeley National Laboratory (LBNL) maintains a database of over 332 RCx projects that have been completed over the last 10 years. A large majority of these projects (84%) were attributable to the efforts of DSM programs. While a few forward thinking companies and government agencies have adopted RCx as best practice, retrocommissioning has yet to see wide spread adoption.

Since the majority of the projects in the database are associated with DSM RCx programs, it should be noted that the database is not a sample of all buildings. The facilities in the database were carefully screened by RCx programs to be cost-effective projects with good savings potential. Most programs screen facilities based on facility size, presence of DDC controls, energy usage, staffing, and maintenance level.

RCx programs either contract directly with commissioning service providers or reimburse customers for the majority of the study costs while requiring the customer to obligate funding towards acting on the corrective measures. RCx programs require more review and oversight compared to traditional DSM programs and, depending on verification requirements, can be quite costly on a per energy unit basis. RCx projects result in heating and cooling savings which may not be able to be claimed by an electric or gas only program.

DSM programs that are evaluated on attribution and freeridership have found RCx programs helpful as they tend to have high attribution rates. The corrective measures that are identified as part of RCx studies either change the practices of facility operators, incorporate new strategies for existing equipment or fix problems that require testing and diagnostics to identify all of which does not take place under normal operation in most facilities.

Spillover is also common in RCx programs as customers will take the lessons learned from retrocommissioning and apply them to all of the facilities in their portfolio. Additionally, some facilities will incorporate commissioning practices into their operations and identify and implement additional measures after the utility has stopped tracking the facility.

## **Program Experience with RCx in Wisconsin**

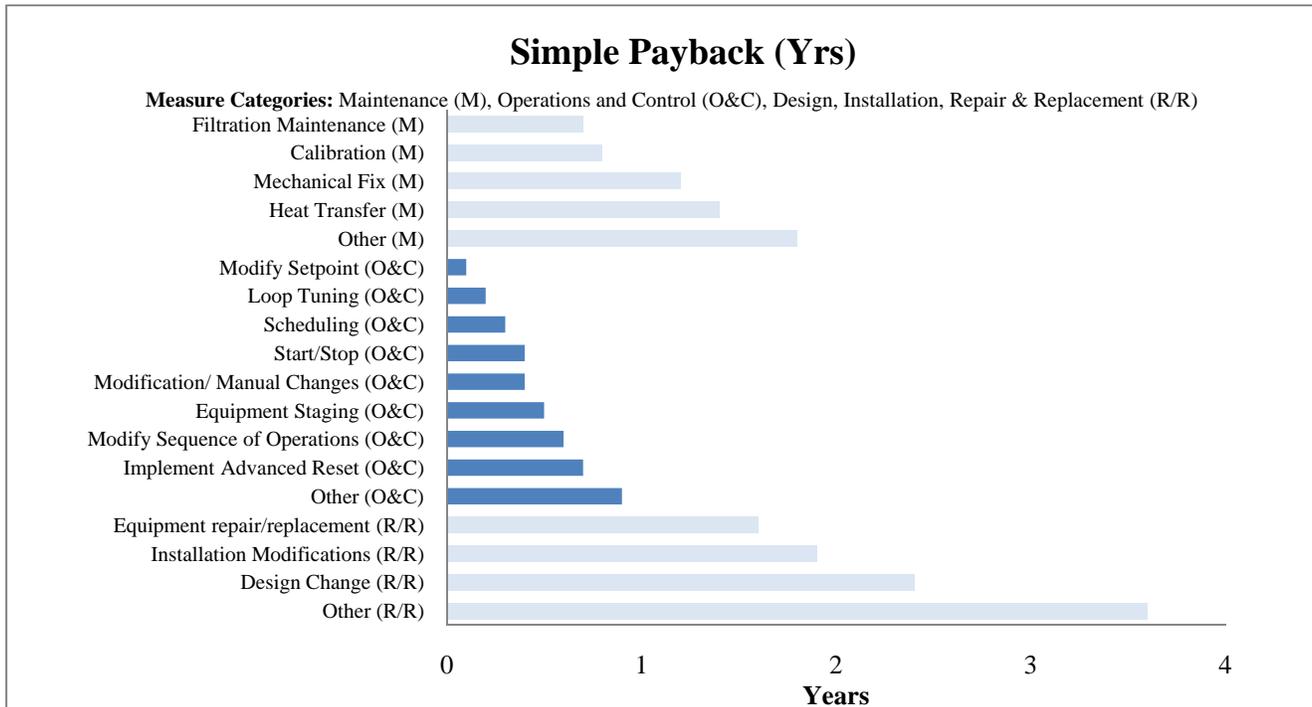
Franklin has been implementing a retrocommissioning program in WI since the beginning of 2008. Many challenges arise when launching a retrocommissioning program within the framework of an existing program including identifying quality market providers, marketing and outreach to decision makers within large facilities, screening participants for potential, coordination and project management for projects that can last a year or longer, technical reviews and verification of implementation and savings are some of the more difficult tasks that are faced when adding RCx to an energy efficiency portfolio. The Wisconsin program has been tweaked over three consecutive program years in order to increase the quality of projects, increase savings and maintain cost effectiveness for the overall program. Businesses totaling more than six million square feet of commercial space have participated in the program to date.

The Wisconsin program follows the traditional five phased approach to RCx with a slight variation in that reimbursements are made at the end of the planning phase and after verification. This program requires that a preliminary measures list is provided at the end of the planning phase in order to help justify proceeding with the project into the investigation phase. Consistently controls modifications are identified immediately in the process and have the quickest paybacks of all the measures identified which reinforces the potential for an offering that targets these measures specifically.

### Findings that Support Modified Approach

One of the many useful statistics provided by the LBNL database is the average payback by measure category. The measures are separated into three categories: Design-Installation-Repair-Replacement, Operations and Controls, and Maintenance. The repair-replacement category covers corrections to design or installation deficiencies as well as system upgrades. The operations and control covers measures that increase system performance by adding or changing controls strategies and operational practices. The third category generally corrects deferred or undiscovered maintenance issues that affect system performance. Figure 1 shows these findings and has been reordered to emphasize that operations and controls measures are consistently the most cost effective.

**Figure 1:** LBNL Payback by Measure Type



The category with the quickest paybacks are the operations and control measures. Cooling and heating systems are designed and selected to meet full load on conditions on the hottest and coldest days with full or no occupancy. Full load conditions are only applicable for a few hours each year at all other times the systems are in part load operation. Most of the operations and controls measures involve programming changes that allow the systems to better respond to part load conditions by incorporating conditional resets and scheduling equipment only as needed. Most operational and control measures can be identified without the need for extensive testing or diagnostics. Operational and control measures are usually advanced control strategies added to the building automation system that were either never programmed or have been underutilized.

PECI evaluated over 122 RCx projects that contained over 950 measures in their 2009 report.<sup>iv</sup> As part of the analysis the top measure categories responsible for 75% of the total savings were identified. In terms of the measure categories established by the LBNL study all of these top measures with the exception of adding VFD's to pumps and repairing leaking coils belong in the operation and control category and do not require testing and diagnostic for identification.

**Table 1:** Top RCx Measures Identified by Peci

Top Measures	% of Total Savings
Revise Control Sequence	21%
Reduce Equipment Runtime	15%
Optimize Airside Economizer	12%
Supply Air Reset	8%
Pump VFD	6%
Repair Leaking Coils	4%
Static Pressure Reset	4%
Optimal Start/Stop	3%
Chilled Water Reset	2%

### **Targeting Operation and Control Opportunities within an RCx Program – Experience at Consumers Energy**

In mid-2009 the Consumers Energy program had to hit the ground running with a requirement for completed commissioning projects by the end of the year. With average retrocommissioning study completion times ranging from six months to one year - not including marketing, service provider selection, and customer recruitment, the program staff was challenged with a timeframe that did not allow for testing a targeted customer recruitment approach and prompted a more expedited method to achieving results.

The program design selected separated the traditional RCx process into three phases: Operation and Maintenance Review, Systems Commissioning, and Systems Optimization. The Operations and Maintenance review phase involves a preliminary review of the facility identifying missing control strategies, opportunities to improve existing controls, and identifying overt maintenance issues impacting system efficiency. Base on the work in Wisconsin, it was felt that the O&M review could be completed with only a few days on site similar to the amount of time spent on site by commissioning providers during a traditional planning phase. The cost per assessment was estimated to be between \$5,000 to \$7,500 based on average planning phase costs and the targeted approach.

### **Partner and Participant Selection**

Franklin sent out an RSVP to qualified commissioning service providers with a challenge. The challenge was to truncate some traditional RCx activities including operator interview, site survey, sequence/mode of operation reviews and maintenance review into a two to three day on-site assessment. It was stressed to potential service providers that this assessment was to determine what control strategies were either not being used or were being underutilized while identifying overt maintenance issues. The focus of the assessment was very different than traditional energy efficiency audits where identifying inefficient equipment and identifying more efficient alternatives is the primary goal.

Grumman Butkus Associates was selected as the primary provider and Environmental Systems Incorporated was selected as the secondary. Providers were selected based on the following criteria:

1. Experience with commissioning practices
2. Knowledge of HVAC system design, operation, and control automation
3. Flexibility to execute three-phase approach
4. Geographic reach

Candidates were recruited by direct outreach from Consumers Energy Corporate Account Managers (CAMs) to their managed accounts with the best potential for meeting the program criteria. Time constraints prohibited an open promotion and recruitment process.

Program personnel set up visits to perform screening audits for potential participants. This audit typically requires 2-3 hours on site and involves an interview of knowledgeable facility staff about operation procedures, primary heating and cooling systems, renovation history and any pending projects that may affect the HVAC or building automation systems. Following the initial audits, candidate facilities were ranked according to five criteria that would justify their potential for the RCx program:

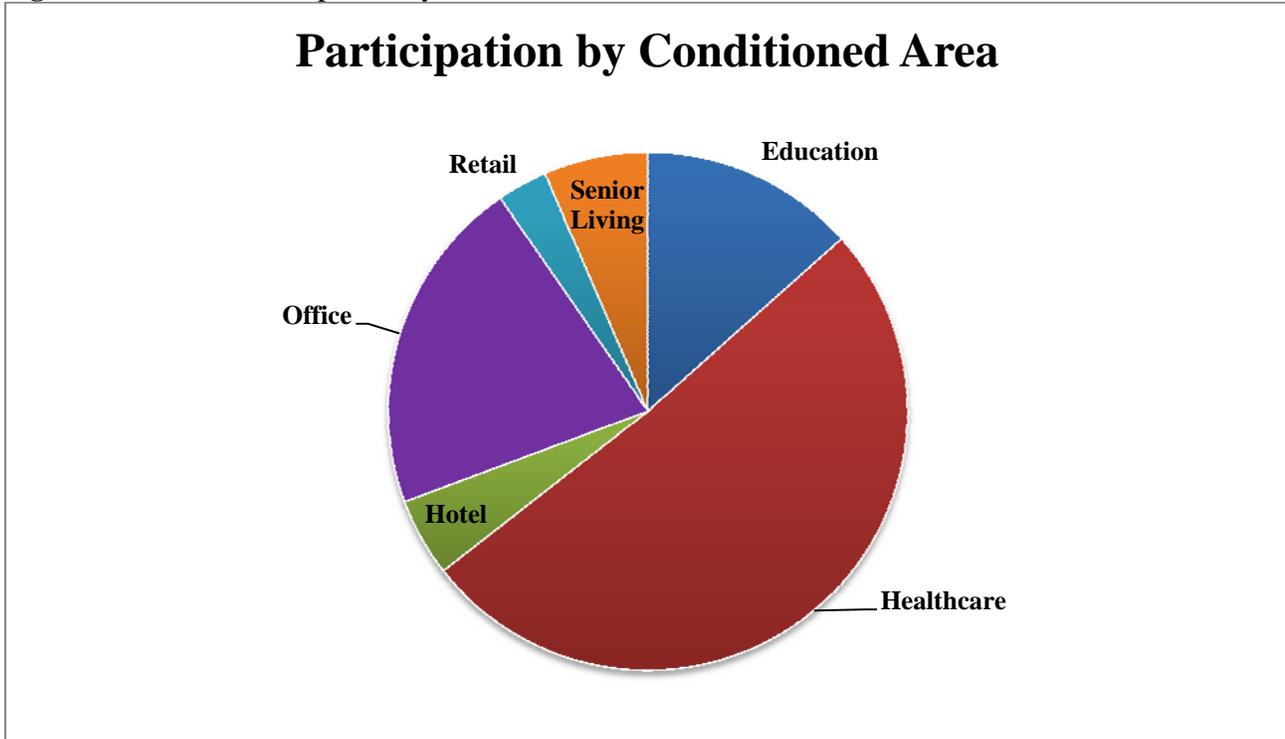
1. *HVAC System Complexity* – The greater the complexity in a system, the less likely it is operating efficiently.
2. *Building Automation System (BAS)* – A large variety of automation systems exist in buildings. Older systems utilize pneumatic controls which require frequent calibration and are limited in their control options. Modern systems utilize direct digital controls that have more control options and feedback from the systems. The ability of the building automation system to trend and store data is important to cost-effective commissioning as it reduces the need for data loggers and test equipment.
3. *Energy Consumption* – Where possible the potential of a facility was evaluated using the ENERGY STAR Benchmarking tool. Facilities that score ‘below average’ (under 50) will have more potential than facilities that score in the ‘exceptional’ range (75 or higher).
4. *O&M Staffing* – The operations and maintenance staff of a facility are integral to RCx success. The facility staff will be responsible for the implementation and persistence of improvement measures. O&M teams should also be knowledgeable of the commissioning process and have buy in to the process.
5. *Maintenance and Capital Planning* – Good RCx candidates have well maintained systems without overt maintenance issues. In order to ensure persistence of improvements, candidates were required to not have major renovations planned that result in the replacement of cooling, heating, or control systems.

## **Phase I Execution**

Thirty-three candidates were submitted by account managers as potential participants. These candidates were asked to submit applications and utility data before being screened for Phase I participation according to the process outlined above. Nineteen of the applicants were selected for participation in Phase I of the program. Applicants had annual energy expenditures ranging from \$135,000 to \$3,100,000. Average annual energy expenditure for the facilities that submitted applications was \$800,000. An overview of applicants by building type is provided below.

A variety of facility types was accepted into Phase I of the pilot program as shown in Figure 2. Healthcare represented the largest group as well as some of the largest facilities in Phase I. With the shortened recruitment time frame, candidates were drawn from the pool of actively managed account of which hospitals made up the largest percentage of non industrial facility types.

**Figure 2:** Phase I Participation by Conditioned Area



Candidates not selected for participation in Phase I received an energy audit that made energy efficiency recommendations based on equipment upgrades and best practices. Energy auditors toured the facilities gathering equipment nameplate, hours of operation, and quantity information sufficient to calculate annual energy savings for a comprehensive list of energy efficiency best practices. Energy audits varied with facility size and complexity but could typically be accomplished in two to three hours with the assistance of facility personnel to act as guide and answer questions.

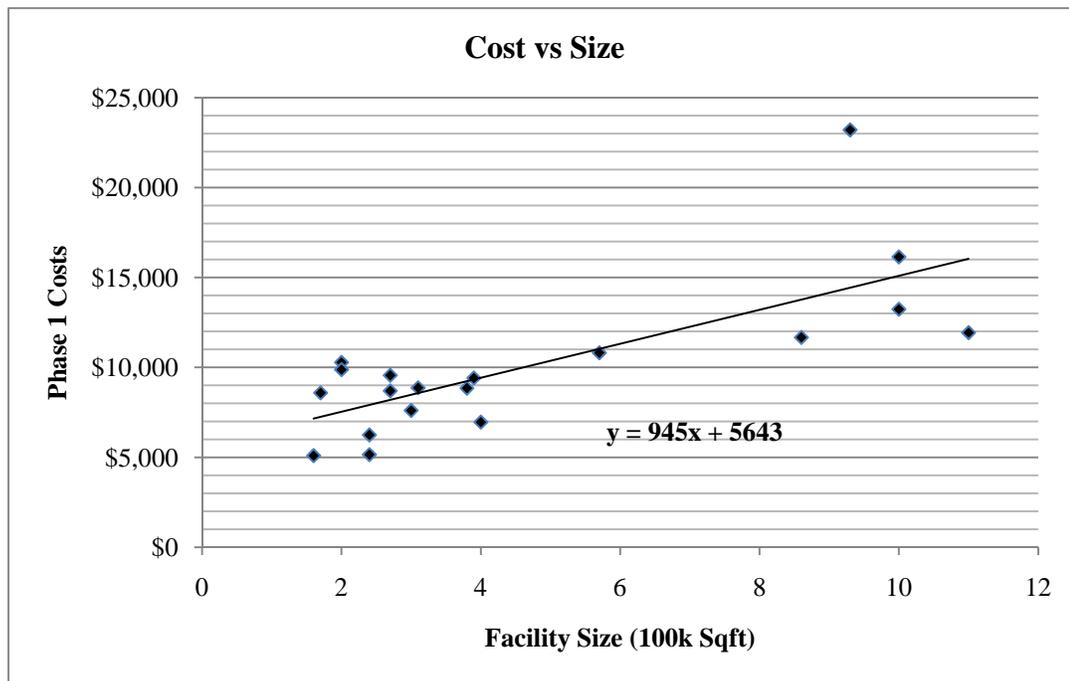
All candidates received an ENERGY STAR [Portfolio Manager™](#) benchmark score provided their facility met the eligibility requirements for the rating tool. Portfolio Manager is an online tool that allows customers to track their energy performance, compare to similar facilities in their region and show improvement over time. The Portfolio Manager tool provides customers with a score between 1 and 100 where 50 represents the average facility. Facilities that achieve a score of 75 or greater may be eligible to certify their facility as an ENERGY STAR building.

Phase I analysis was performed at 19 facilities for a combined conditioned area of 8 million square feet. From this analysis commissioning firms identified 245 measures that have a savings potential of over 8.1 million kWh, 94,000 Mcf, and \$1.6 million in annual energy savings for customers. While all facilities in the pilot were Consumers Energy electric customers, only a portion of the customers were also Consumers Energy natural gas customers. The natural gas savings identified for Consumers' customers was close to 34,000 Mcf (36% of the total). Implementation of all the savings identified would result in an average savings of 4.5% of electrical consumption and 10.9% of natural gas use.

Professional fees for the 19 facilities came in at \$192k or about \$10,000 per facility. Work for Phase I was contracted on a time and materials basis due to the lack of familiarity by the subcontractors on the O&M review approach. Professional fees on a per square foot basis were \$0.024 per square foot. Figure 3 shows the relationship between facility size and study fees for the O&M review. The trend line

for graph shows the average cost was a base rate of \$5,600 plus \$1000 for every \$100k square feet of space evaluated per site.

**Figure 3: Phase 1 Costs**



Hospitals made up 50% of the conditioned area evaluated, while measures associated with the hospitals accounted for 63% of the savings identified. Hospitals are large facilities with high energy consumptions per square foot than most other building types. Hospitals made up a large number of the managed accounts from which the candidate pool was selected. Hospitals also tend to have more updated controls systems that allow for successful implementation of energy savings control strategies.

**Table 2: Phase I Results**

Simple Payback	# of Measures	% of Measures	% of Savings	MWh	Mcf	Savings
Immediate Payback	45	28%	35%	3,380	21,055	\$508,900
.5 to <1 yr	17	11%	12%	1,019	8,103	\$165,732
1 to <1.5 yrs	12	8%	7%	592	6,118	\$98,450
1.5 to <2 yrs	7	4%	3%	312	14,118	\$40,550
2 to <5 yrs	25	16%	12%	1,484	7,687	\$192,743
5 yrs or more	42	26%	16%	1,250	8,130	\$230,413
Needs Investigation	97	8%	15%	110	28,770	\$220,375
Grand Total	245	100%	100%	8,146	93,979	\$1,457,163

Table 2 shows the results of Phase I operation and maintenance reviews. Of the measures identified, 75 have a quick payback of 1.5 years or less with an energy savings of 5 million kWh, 35,275

Mcf, and an annual energy savings of \$800,000. Forty five measures had a payback of less than 6 months or less with an energy savings of \$532,900.

**Phase II execution**

Phase II participants were selected based on the amount of savings identified in Phase I, potential savings based on similar projects, recommendations made by commissioning teams, and customer buy-in. Funding was limited for the pilot and Phase II costs were significantly higher, average cost for Phase II was \$42k per site versus \$6k for Phase I, so the number of participants had to be reduced. As with traditional RCx programs customers were required to commit to \$20,000 for the implementation of measures with a payback of less than two years. The implementation requirement was limited to \$20,000 yet it included the measures identified in Phase I that needed additional investigation. Customers were encouraged to implement all cost effective measures but were provided a minimum in order to get project approval from financial decision makers.

**Figure 4:** Pilot Participation by Phase and Type

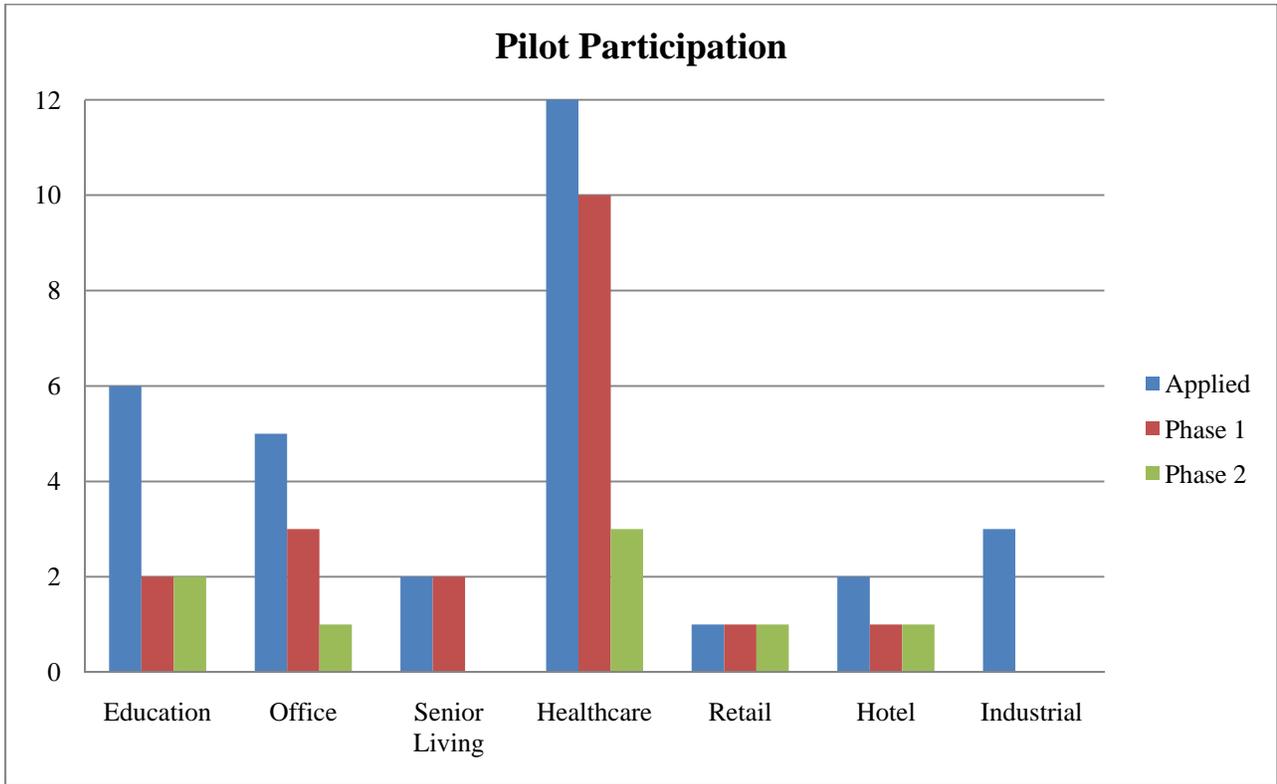


Figure 4 shows the pilot participation by facility type during each of the phases. The industrial applicants didn't meet the selection criteria. Funding was limited for phase II, so only eight of the phase I participants were selected for phase II. The facilities selected for phase II had a combined 4.9 million square feet of conditioned space. The total professional fees for performing commissioning at the 8 sites were \$340,000 which equates to \$42,500 per site or \$0.069/square foot.

**Table 3: Total Savings Identified by Phase**

<b>Phase 1 O&amp;M Review</b>				
Facility Type	Educational	Hospital 1	Hospital 2	Hospitality
Savings Identified	\$52,938	\$345,673	\$97,475	\$78,275
Immediate Payback	\$41,900	\$241,750	\$92,350	\$54,300
< 2 yr payback	\$4,250	\$88,048	\$5,000	\$18,200
> 2 yr payback	\$6,788	\$15,875	\$125	\$5,775
Total Time (weeks)	4.0	3.0	3.0	3.0
Fees	\$23,207	\$8,866	\$13,234	\$9,407
<b>Phase 2 Traditional RCx (Savings Beyond O&amp;M Review)</b>				
Additional Savings Identified	\$4,600	\$28,650	\$45,700	\$115,625
Immediate Payback	\$4,200	\$26,750	\$9,050	\$89,450
< 2 yr payback	\$400	\$1,900	\$17,450	\$25,950
> 2 yr payback			\$19,200	\$225
Total Time (weeks)	33.0	33.0	33.0	33.0
Fees	\$51,520	\$33,800	\$52,600	\$32,990
<b>Sum of All Phases (Expected results of Traditional Approach)</b>				
Total Savings Identified	\$57,538	\$374,323	\$143,175	\$193,900
Fees	\$74,727	\$42,666	\$65,834	\$42,397

The cost savings identified by phase for four of the eight projects selected to move into phase II are shown in Table 3. Savings identified shows the first year annual savings of the measures uncovered as part of the O&M review. The measures are further broken down by payback to show that most of the measures would be attractive to customers based on payback. In three of the four sites the O&M review identified the majority of the savings opportunities at a fraction of the cost. The savings identified under the Phase II section represents additional savings uncovered as a result of trending, diagnostics and functional testing. Adding the savings identified under each phase is a good predictor of the results of a traditional commissioning approach without a dedicated O&M review. The time for each phase was the duration from site visit to report delivery. Most of the Phase 1 assessments were completed by two person teams with two to three days on site. Some of the campus style or million square feet facilities required three man teams or four days on site. Phase II assessments required multiple site visits over the course of several months to gather all the data.

The education facility had the least amount of additional findings as result of the commissioning activities. This facility was close to a million square feet and included multiple buildings, which made it an outlier for Phase I and II costs. The facility was well maintained but was missing key control strategies which resulted in nearly all of the opportunity being identified by the O&M review. The hospitality facility on the other hand had a host of issues identified as a result of functional performance testing and diagnostics in addition to the control strategies and overt maintenance issues identified in Phase I. The hospitality facility represents a facility best served by the traditional approach.

It is important to distinguish between savings identified and savings implemented. Retrocommissioning programs have difficulty getting customers to act on all the recommendations provided. Even quick or immediate payback measures may go unimplemented by the customer for a variety of reasons. The implementation commitment that many programs require acts as a safety net for

the program by requiring the customer to have implementation funding set aside above and beyond whatever cost share they have for the professional fees associated with performing the investigation. At the time of the report the implementation activities were ongoing and the final implemented numbers were not available. The immediate payback measures are expected to be a conservative estimate of savings achieved.

The projects selected for Phase II had the greatest potential for identifying additional savings during the commissioning process. This choice was made to ensure that the relative benefit of Phase I on a dollar per energy savings basis would not be overstated with respect to Phase II opportunities. In other words, the savings identified during Phase I for these sites as a share of the total savings identified during Phase I and II will be lower than facilities with less potential.

All of the candidates submitted for participation in the program were larger than average facilities by RCx standards. The same tests are needed to evaluate similar air handlers regardless of facility size. Since the costs for each of the assessments are approximately the same, the greater energy savings realized in larger facilities translate to a higher energy savings per dollar spent on retrocommissioning activities. As a result, the cost effectiveness observed in the pilot somewhat overstates that cost effectiveness of a program that would target a more representative population of buildings appropriate for RCx.

## **Weighing Tradeoffs**

An O&M review is not commissioning. While achieving cost effective energy savings is a benefit of commissioning it is not the only goal. Commissioning seeks to correct all deficiencies, optimize operations and maintenance practices, train staff and add quality checks that insure continued performance in the future. If customers only meet the minimum implementation requirements of a program and do not change operation and maintenance practices or train staff then commissioning hasn't been achieved.

That being said there are many DSM sponsored commissioning projects that do not result in a facility being commissioned. Many customers' sign on to RCx programs with the promise of a quick payback and energy savings yet are reluctant to follow through with the infrastructure changes or capital costs of bringing the systems to peak performance and maintaining them at that level. Many facilities also have difficulty acting on all of the findings of a commissioning study because they don't want to admit fault for operating the facility in an inefficient manner. Getting a successful commissioning project goes beyond owner buy-in, you also have to have the facility team's buy in as well. Without the facility team's buy-in, facility measures that are put in place can be overridden or teams can countermand recommendations when decision makers turn to them for technical advice. Facility staff often does not have the correct incentives to operate a high performance building as they are often evaluated strictly on minimizing complaints and down time without any consideration on how their performance impacts energy costs..

The question then remains should the DSM program remain altruistic to the goal of achieving commissioning at every facility in their commissioning program or should the program promote full commissioning while maximizing cost effectiveness for ratepayers by offering more limited engagements, such as O&M reviews, to customers who only wish to achieve quick paybacks. The operation and maintenance reviews offer a great tool to determine how effective full retrocommissioning will be by assessing how much of initial recommendations are acted upon and how readily the changes are internalized into how they do business. At a fraction of the financial obligation and time commitment operation and maintenance reviews can identify a majority of the potential savings of a traditional RCx project in most facilities. This lowers risk for the utility and customer and allows more market penetration.

## **Beyond the Pilot**

Moving forward the commissioning pilot program will test the targeted approach on a wider sample by promoting to all Consumers electric customers with 75,000 square feet or more of conditioned space with direct digital controls. Applicants will be screened for the presence of DDC controls, willingness to meet an implementation requirement of \$5,000 and verification that major renovations of key systems are not planned in the near future. Participants who implement all of the low cost recommendations identified in the O&M review and have potential for commissioning will be invited to a 50% cost share on a full RCx offering. Should the cost effectiveness of the first round of the pilot hold with open enrollment and smaller facilities, the program should be able to help a larger pool of customers with less risk, quicker turnaround time and more cost effectively than a traditional RCx program.

## REFERENCES

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