Program Results from the State of Minnesota's Existing Building Commissioning Program

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Synopsis

The State of Minnesota's Public Buildings Enhanced Energy Efficiency Program (PBEEEP) is modeled after other successful utility recommissioning programs. The Center for Energy and Environment's (CEE) goal for PBEEEP was to transform the existing building commissioning (EBCx) market in Minnesota from an audit based approach to a data-based investigation to achieve verifiable, persistent savings.

This paper provides the results of energy investigations of 227 buildings containing nearly 19 million square feet located on 50 sites throughout the state of Minnesota. The participation rate in the program was very high (75% of the targeted buildings), which provides a useful measure of the potential for broadly implemented existing building recommissioning programs. Several best practices for program managers were identified, as well as a number of lessons learned that surfaced as the result of a rigorous quality assurance process. Our experience highlights the need for a training and certification process for EBCx providers if customers are to receive consistent, high quality projects.

About the Authors

Chris Plum is a program manager with over 20 years of experience managing projects, including research and development projects. He currently manages the State Government Public Buildings Energy Efficiency Enhancement Program (State PBEEEP). Since earning his PhD in Chemistry at Cornell University, which focused on energy transfer in chemical processes, Chris has worked in the areas of carbon dioxide sequestration, process efficiency, market research and property management. He is a project management professional. He has a BA in Chemistry from Swarthmore College and an MBA from the University of Minnesota.

Mark Hancock has twenty three years' experience in energy efficiency in institutional, commercial and residential buildings, with an emphasis on building automation, field diagnosis of HVAC systems and deployment of data logging systems for documentation of system performance. He has been the program director for the Public Buildings Enhanced Energy Efficiency Program for the last four years. He has extensive experience in building system operation, optimization, and diagnosis. He has also been involved in a broad range of field research for gas and electric end uses including ice arena desiccant dehumidification, commercial gas and electric cooling, commercial and residential gas space heating, commercial

and residential water heating, commercial cooking, and industrial process consumption. Mark holds a Bachelor of Science in Mechanical Engineering from the University of Minnesota, is a registered professional engineer in the state of Minnesota, and has worked at CEE since 1987.

Christie Traczyk has over seven years of experience working in R&D and production-level manufacturing roles, quality and reliability roles, and project/program development and management roles. She has worked in a variety of industries including industrial gases, heavy equipment, oil and gas, transportation, and university research. She has also supported research projects and LEAN/Kaizen initiatives in commercial and residential buildings programs. Christie has a B.S. in Mechanical Engineering from Michigan Technological University and an M.S. in Industrial Engineering from the University of Minnesota.

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Background

To have an impact on the nation's building energy use existing buildings must be addressed. Existing building commissioning is the process of investigating and optimizing the performance of a facility through detailed investigation of its systems. The goal is to make existing building systems perform as intended or meet the current needs of the building, post construction. CEE has previously noted that the number of buildings that are good candidates for successful existing building commissioning projects appears to be lower than has been projected in other studies and should be considered by policy makers, utilities and practitioners who need to manage expectations of their services. In this paper we report on energy savings found from a comprehensive study of facilities that make up 44% of the total energy usage of state government buildings.

For the existing building commissioning industry to grow and deliver the all potential savings to their customers (whatever the absolute magnitude) best practices are required. The results in this paper show the importance of a quality assurance program, active customer engagement and follow-up to overcome barriers to implementation. These services can be provided by a third partner administrator or a utility company. By maintaining a close, on-going relationship with the customers, a measure implementation rate of nearly 80% can be obtained by other programs following the recommendations made in this paper.

Legislation was enacted in Minnesota in 2008 to encourage existing building commissioning of all state government-owned buildings as a means of reducing the state government's overall energy use. Subsequently, the State of Minnesota chose to allocate American Recovery and Reinvestment Act (ARRA) funds to this program, which increased the potential size of the program while effectively shortening the timeline. In a previous paper we reported interim results of PBEEEP, including the necessity for building screening and the potential for savings in a large pool of buildings (Plum et al. 2012). We update those results here and add information on

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the impact of the quality assurance process and information on the measures selected for implementation.

The Program Design

PBEEEP's initial design was centered on CEE's past recommissioning experience which focused on data and labor intensive activities. Our approach, which the program sought to have others adopt, involved a staff of three to four engineers dedicated to existing building commissioning. The approach limited our capacity to less than ten projects a year. While elements of the program have evolved based on our recent experience, the approach remains data intensive, relying on trend data (typically collected continuously from several hundred points from the Building Automation System (BAS) at 15 minutes intervals for at least six months) to identify and quantify energy saving opportunities that are unlikely to be found by observation or functional testing. This approach is distinctly different from an audit based approach where walk through observations plus interviews with the building staff are used as a basis for energy conservation recommendations. An auditor generally spends less than 20 hours in a building. In fact, we use an assessment much like an audit to determine if a building is a good candidate for an investigation; it is the start of the process, not an end in itself.

With the trend data based approach data is collected for at least six months, effectively putting the building analyst on site for over 4,000 hours on a 24 x 7 basis. Temperature dependent data is collected from winter lows to summer highs, a range of about 100 degrees in Minnesota. The engineer can see how the systems run under design conditions and everything in between. While this has always been CEE's approach, it does not represent the norm for recommissioning providers in Minnesota. One goal of CEE was to use PBEEEP to encourage this market transformation.

CEE is the program developer and administrator of PBEEEP; the actual site work was performed by engineering firms that were on a master roster of energy engineers that was established prior to the roll-out of the program (State of Minnesota, Department of Administration, Real Estate and Construction Services. 2009). Because the roster RFP preceded the program, prior existing building commissioning experience was not a qualification for these firms. This created significant challenges for the program and is not recommended as a best practice. As discussed below, training and precertification of providers will produce higher quality results. A dozen firms were on the original list, seven ended up working successfully in the program.

CEE worked with Portland Energy Conservation, Inc. (PECI) to create the detailed program. PECI is well known for their utility recommissioning program management and design work, especially in California. Like these programs, PBEEEP was designed with four phases: Screening, Investigation, Implementation and Measurement/Verification. Key elements of this program are: written performance guidelines, an ever-increasing body of training materials, and a rigorous review of all proposed energy savings measures, including supporting data and calculations, completed by experienced mechanical engineers (Minnesota Department of Administration, 2009). The provider firms submit their findings to the program administrator

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who reviewed them for merit and then formatted the final report. Not all submitted findings made the final report due to errors in calculations and lack of supporting documentation.

The program budget was developed using information on other programs and from the literature (Mills, 2009). The state of Minnesota, Department of Administration, planned to provide 25% co-funding for all projects (for the screening and investigation phases only) in addition to paying for the administrative and quality assurance costs. The program cost model assumed the following:

Table 1: Cost/Benefit model used to establish PBEEEP budget

Costs	Budget cost ($/ft^2)	Benefits	Budget value
Investigation	$ 0.25	Energy Cost	$1.60/ft^2
Implementation	$ 0.70	Expected Savings	10%
Administration & QA	$ 0.05	Value of Savings	$0.16/ft^2
Less 25% cost share	($ 0.25)	Simple Payback	4.7 years
Net Cost to customer	$ 0.75		

When ARRA funds became available, they were applied directly to the upfront co-funding costs and the 75% cost sharing requirement was not enforced. Actual program costs were different; quality assurance costs were much higher and implementation costs appear to be lower, although implementation is not yet complete at most sites.

Characteristics of the Minnesota State Government Building Population

Public buildings have many distinct characteristics that have an impact on their potential opportunities for improved energy efficient operations. The 3,407 state buildings include many that are "non-standard" compared to building types found in CBECS or ENERGY STAR's Portfolio Manager, so that only 57 qualify, based on space usage type, for a Portfolio Manager score, and of these, only nineteen buildings are larger than 50,000 sq ft. Among the building types included in PBEEEP, but not represented with benchmark values in Portfolio Manager are 9 state prisons; 32 community colleges, 5 state universities, 3 laboratory buildings, 7 parking garages, a museum, and the state capitol building. Other distinct features of the sites in the program include the fact that twenty five of the 71 participant sites have central plants that serve multiple buildings (generally with no building level sub-metering) and twelve buildings are served by district energy systems.

The sites participating in the program are served by 37 different utility companies, including 10 investor owned utilities, 26 municipal and cooperative power companies and one federal power distributor (WAPA). Three of these utilities offered rebates for recommissioning studies and many offer prescriptive rebates for installed equipment, although some of the municipal utilities do not offer any incentives for efficiency improvements at this time.

Minnesota has an energy tracking database of all government owned buildings, Minnesota Benchmarking and Beyond (B3), which was helpful in site identification and recruitment

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(Minnesota Benchmarking and Beyond Database at http://www.mnbenchmarking.com). The database includes building size, building age, space use types and utility history. All data is self-reported, so the data requires verification to be reliable. Considerable effort was spent by PBEEEP administration to bring sites up to date, and to keep the data current during program activity. We found that many of the sites do not regularly consult this database and that it is often updated by a member of the administrative staff (the person paying utility bills), not the facility staff (the people making energy decisions). The database includes a calculated benchmark value based on standard building models using the State's current energy code; according to this measure, the average building in the dataset has energy use 28% better than code. There are 45 basic space usage types that are modeled, tailored towards the building types found in government. As the benchmark is based on performance relative to code, it is a less aggressive relative rating system than ENERGY STAR Portfolio Manager.

Screening Results

Screening was used to identify buildings where an energy investigation would be cost effective. Figure A illustrates the effect of the building selection criteria on the total population of buildings and the fraction of energy that remained after each selection criterion was applied. All told the 3,407 buildings, which are located on 1,428 sites throughout the state, used approximately 4,860 MMBtu in 2012. Those over 50,000 square feet were eligible to apply for the program, eliminating 90% of the sites, but only 11% of the total energy use. Of these, about 75% applied to the program, and their total energy use was 3,000 MMBtu, over 60% of the total. (The other eligible buildings, which use about 25% of the total energy, were already engaged in energy conservation programs). The screening process further reduced the buildings to be investigated, so that in the end the buildings in the program accounted for about 44% of the energy usage of state owned buildings or approximately 2,100 MMBtu.
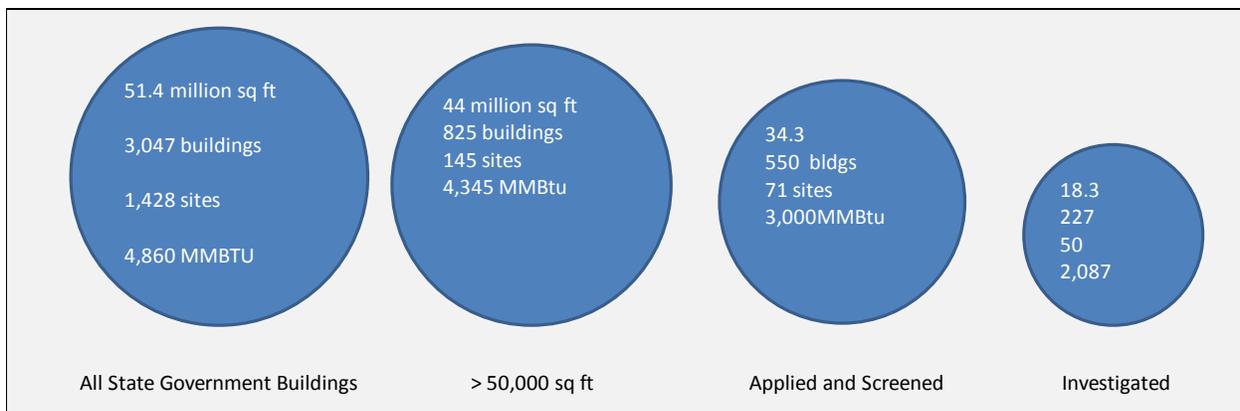
Figure A. Building selection process, scaled by total building energy use

Participation in PBEEEP was very high: as a comparison, during the same time period the recommissioning program of the state's largest utility had a similar level of absolute activity (based on reported number of participants and energy saved) on an energy base that is about 25 times as large as the state buildings, as is summarized in Table 2.

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Table 2. Comparison of PBEEEP with a large MN utility RCx Program

Note: PBEEEP savings are based on findings identified in the study, which can include retrofit measures and not all measures will be implemented; the utility program savings are traditional recommissioning measures that have been implemented; savings from studies that have not been implemented would be higher. The count of utility customers is all non-residential customers.

Program	Sites/ Customers	Total System Energy (MMBtu)*	Program Sites/ Participants	kWh Savings** Identified/ Reported	Dt Savings** Identified/ Reported	$/MMBtu Saved***
PBEEEP 2010-2012	1,428	4,860	71	17,800,000	95,600	$21.07
Large MN Utility RCx 2010-2012	160,000	120,500	447	29,600,000	58,000	$23.65

* Total energy expressed for PBEEEP it is based on data reported in B3 as used by all state building; for the utility it is based on their annual reported non-residential electric and gas sales.
** PBEEEP Savings are calculated, but not yet implemented, Dt savings include district energy
*** Cost for the utility is total reported program cost, for PBEEEP it is the investigation cost

Screening involved site visits by the program after receiving an application. Screening visits take at least half a day and often a day or more (4 hours minimum for up to 300,000 ft^2, one additional hour per 100,000 ft^2 hour after that). An engineer and program manager not only inventoried equipment at each facility, they also assessed age and condition of mechanical equipment, the level of building automation, hours of operation and facility management practices. Screening by the program staff had numerous other benefits, including a consistent approach to all the sites and an opportunity for the program engineer to become familiar with the site prior to the start of the third party investigation phase of the project. Screening by the program also allowed a more in-depth and unbiased assessment of each facility than an application form, while still keeping costs low (about $0.013/ft^2). We recommend it as a best practice.

We modified the metrics published by PECI for their California based programs to tailor them to the climate of Minnesota. The key metrics that differed between the two programs were:
- motor sizes (>10 HP is good) were used instead of HVAC cooling capacity (reflecting the difference between a heating dominated climate, Minnesota, and a cooling dominated one, California)
- absolute energy intensity was used instead of the ratio to benchmark (in part because most of our buildings types are not in the CBECS data)
- hours of operation was used to capture the potential for scheduling based measures.
- building automation systems (BAS) with digital direct control (DDC) that had the capability to trend and save large amounts of data were strongly preferred
- the observation of potential for optimization of operations was a requirement.

As a result of the screening 28 sites, with 19% of the total building area, did not go forward to the investigation phase. Most of the disqualified sites had much lower than average energy use

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and several of them had recently undergone major upgrades and were still in the warranty period. At the 43 remaining sites where investigations were performed individual buildings making up 22% of the building area were eliminated from further investigation (small buildings at some sites and dormitories on university campuses).

There were a variety of reasons that some facilities chose not to participate in the program. The most common were that they were already involved in an energy conservation program, had previously engaged in energy conservation efforts and now had below average energy use, or had an active major construction project involving their mechanical systems. In retrospect, some sites were included that should not have passed the screening process. These included:
- sites that were mandated for political reasons (for example to have all state agencies participate, or the referral of a utility account representative)
- lack of building automation systems
- presence of many small systems and those with equipment that was independently controlled (not integrated with BAS)
- significant restrictions on operations that conflict with potential energy savings measures (prisons with 24 x 7 operation and ventilation requirements based on the presence of a toilet in each room).

Investigation Results

On a program level, savings of 7.2% overall were identified, with a range from 1.0% to 27% per site. Large savings were even found in sites with moderate energy use, similar to the results of Falk et al. (Falk et al. 2010). The average number of findings per building was 2.5 with a range from 0 to 14. As many as 45 findings were identified at large multi-building sites. The number of measures identified is not just dependent on the site; it also was dependent on the provider doing the work, as is discussed below.

The measures identified in PBEEEP are shown in Table 3. Savings are expressed in $kBtu/ft^2yr$ of site energy. They are consistent with those found in other existing building commissioning programs, both in frequency and magnitude (Criscione, 2008, Della Barbra 2005, Effinger et al. 2009).

Many of the average savings per measure are larger than those reported by Effinger et.al (who reported an average value of 0.5 $kBtu/ft^2yr$ vs. of 2.1 $kBtu/ft^2yr$ here), but the number of measures per building is smaller in our populations (2.5 vs. 8). We did not calculate building level saving at those sites with multiple buildings due to the lack of submetering. The overall savings per site for measures paying back in 3 years or less is 5.8 $kBtu/ft^2yr$, twice as high as the value of 2.9 $kBtu/ft^2yr$ found by Effinger et. al. Our average total savings per site of 8.1 $kBtu/ft^2yr$ is consistent with the trend they observed of greater savings as the ASHRAE Climate Zone number increased; our results are close to those reported for the coldest climate zone in their study, 5A (7.61 $kBtu/ft^2yr$). Minnesota is in climate zones 6A and 7A. As would be expected, the measures found in Minnesota are primarily ones that save energy in the heating season, not the cooling season, another difference from other studies that have included a large number of buildings where cooling was the dominant energy use.

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These ten top findings account for slightly over 80% of all measures and 80% of all savings. It is notable that there is a broad range of paybacks from just over 6 months to 11 years. The column titled affected area is the percentage of total building area investigated for each finding; the total of 412% means that there was an average of 4.12 findings per building.

The top three finding types, related to scheduling and proper use of economizers for outside air requirement or 'free cooling' were found in 2/3 of all buildings, more than five times the frequency of the 'average' finding type. The fourth finding type, lighting retrofits, was only found in about 1/3 of all spaces, indicating that, at least in these buildings, lighting no longer represents a prime opportunity for energy savings (because the retrofits have already been completed).

Table 3. Summary of Most Commonly Identified Energy Savings Measures

Number	Finding Type	Payback (years)	Affected area (%)	Site energy savings kBtu/ft^{2}yr
135	Time of day enabling is excessive	1.1	66%	3.3
97	Economizer operation not optimal	4.4	71%	2.0
88	Excess enabling of equipment	0.7	68%	2.1
88	Retrofit - Efficient Lighting	8.2	33%	1.2
44	Zone setup/setback	0.9	16%	2.6
23	Other controls	11.3	14%	3.1
21	Lighting on more hours than necessary	4.7	12%	1.1
21	Other retrofit (mostly faucet aerators)	1.9	10%	0.8
17	Deferred maintenance	2.9	12%	1.2
14	Leaky/stuck valve	1.9	4%	3.9
116	All others	6.7	107%	1.7
664	Total	3.9	412%	2.1

The top 3 findings are consistent with recommendations for primary opportunities likely to be found in all buildings (Murphy and Maldeis, 2009; Moser, 2013). While it is tempting to consider an "EBCx light" approach that looks only at these measures, that would ignore about 45% of the potential savings in these buildings.

There is also a very wide range of cost to implement a given measure as shown in Table 4. It is noteworthy that the cost per measure does not have a direct relationship to the payback period – one of the key reasons that accurate cost and savings calculations are required to best serve the needs of the customer. It should also be noted that while the estimated cost for a single controls change was on the order of $2,000 multiple changes can be made in a single service call lowering the cost by up to 50%. Many of the sites plan to implement controls changes over time at 'no cost' as part of their regular maintenance contract with their controls contractor.

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Table 4. Implementation cost for selected finding types

Finding type	# Findings	Cost per Measure	Simple Payback (yrs)
Retrofit – boilers	3	$250,352	11.3
Retrofit - energy/heat recovery	5	$94,305	8.7
VFD Retrofit - Pumps & Fans	21	$32,371	9.9
Time of day enabling is excessive	135	$3,422	1.1
Excess enabling of equipment	88	$2,302	0.7

There are two conclusions to be drawn from the results of the investigation reports: the first is that when a higher fraction of the potential existing building stock is included in an existing building commissioning program the average savings per building may be somewhat lower than expected; however total savings is increased, and, with appropriate screening, savings were found in all facilities.

These results need to be considered in of statements that promise large savings in all existing buildings. The results here, which are consistent with those published by Effinger et al based on a survey of 122 projects in 11 different utility programs, indicate that the savings from existing building commissioning are often in the range of 5 to 10% of total building energy. Our observations, discussed in detail below, also indicate that even these savings require training and skilled personnel to achieve. Creating unrealistic customer expectations that may not be possible to meet can ultimately hurt the credibility of the existing building commissioning industry: projects which fail to deliver expected savings will be seen as a failure by the provider by many customers.

The Need for Quality Assurance

The results reported above were not taken directly from the reports submitted by the program's providers. As program administrators, we served as an owner's representative, assuring that promised savings could be delivered at the reported costs. To this end, the findings were submitted to us in a Microsoft Excel® workbook, called the Findings Workbook. All calculations, and their supporting data, were reviewed by the program engineers prior to approval of each energy investigation. A midpoint review was performed on the results from the first major season (heating or cooling) and again at the conclusion of each project. Our original expectation was that the initial review at the project mid-point would point out places where calculations were incomplete or assumptions were unclear. Those issues would be corrected and applied to the final submission, which should only need minor additional revisions, if any.

The seven providers each performed between 4 and 9 projects (one site per project) with a range of 15 to 39 buildings. The average building area investigated by each provider was 2.6 million square feet, with a range of 1.96 to 3.56 million square feet. The total number of findings submitted for final review varied from 85 to 276 per provider, with an average of 151. The quality assurance analysis below is based on these findings.

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In actual practice, we found many serious deficiencies in calculations and unwarranted assumptions. This added time and administrative cost to the overall process as each workbook was submitted an average of 4.1 times, rather than the expected two. The average engineer's review time per project (site) was 80 to 100 hours. Because most firms postponed doing many of their detailed calculations until their final submission they did not get the important mid-project feedback. One provider's contract was terminated for this reason (they were unable to submit acceptable support for any findings in a timely manner). Many calculations were done in a manner that could not be addressed by a minor correction and the reviewing engineer often ended up going stepwise through the process, so that multiple resubmissions were necessary. In some cases the providers deleted what appeared to be good findings rather than performing the calculations correctly. In the most extreme case, a provider deleted about 2/3 of their original list of findings when they discovered that a rigorous calculation would be required. While it was not our intent, the reviewing engineers were training many of the providers through the review process.

As the calculations were revised, the reported savings became more realistic. We audited the original version of the Findings Workbooks accounting for 2/3 of the total energy savings submitted to the program. We found that the savings reported for a given finding were decreased about 66% of the time, were within 2% of the approved value 14% of the time and increased 20% of the time. Overall, the initial error rate of 86% was far greater than we had expected.

Based on this audit, the originally submitted savings were overstated by approximately 75%. The implication is that without the rigorous quality assurance process, the program would have reported identifying savings of about 12.5%. While this would have exceeded our expectations, it also would have been incorrect. The ultimate test of the calculations will come following implementation at the measurement and verification stage, which are not yet available. The reported results are based entirely on calculated potential savings.

The graphs below summarize the major lesson learned in the program: that without a rigorous provider qualification (and training) process, individual results are likely to be dependent on the team that performs a project. In each of these graphs the providers are kept in the same order, identified by letters (A, B, C, D, E, F, and G). The ordering A $\rightarrow$ G is their rank order based on total approved energy savings divided by the total area in all their projects. It does not necessarily follow that this is overall competence due to variation in savings potential across sites, but there is certainly a general trend.

As Figure B shows, for most providers, their reported savings were reduced, but in one case the reviewers identified increases in savings. Decreases were due in part to measures that were fully deleted (see Figure E), but more often to those with overstated savings. The reason that deleted findings did not have a major impact is that approximately half of the deleted items were never submitted with completed calculations. In some cases findings were listed on the first submission as potential issues that required further study (but then were not actual problems); in other cases the finding was based on a back of the envelope calculation that was not submitted. Provider F, who had the lowest average savings per site, the reported savings was increased by an average of 8%. This, unfortunately, was not due to a conservative approach on their part, but

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rather because the calculations were incomplete, leaving out valid savings as originally submitted. The program's engineers worked closely with the engineer who submitted these calculations, much like working with an intern. The provider did learn how to better identify savings, and was able to apply this to a large government office building in his final project, producing savings of approximately 9%.
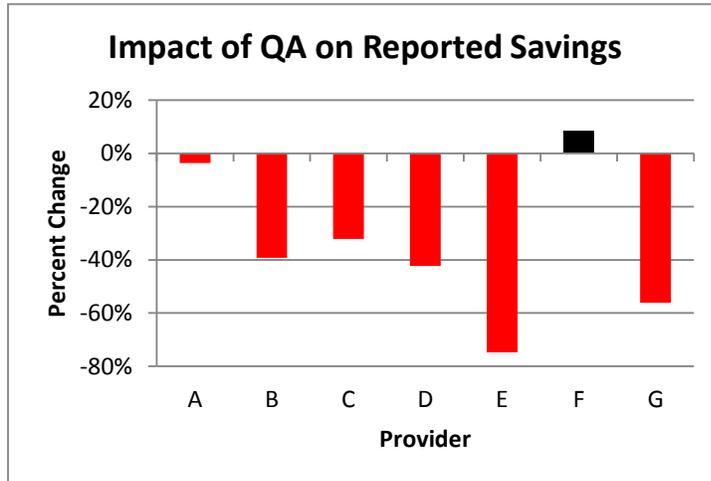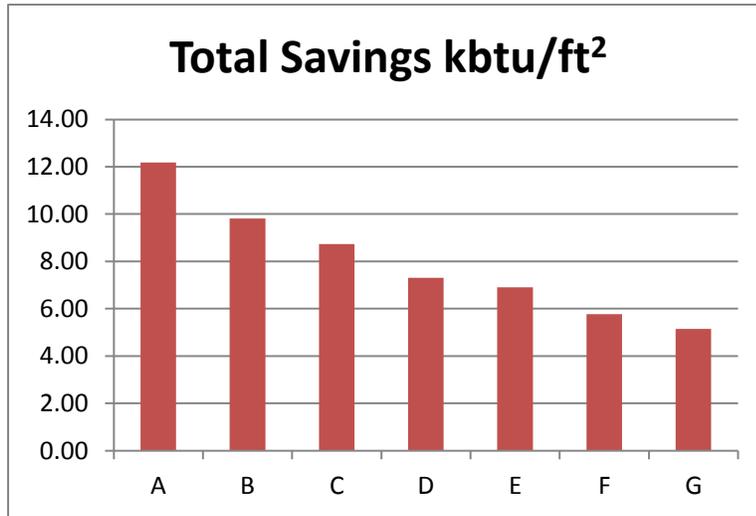

Figure B. Effect of quality assurance review on initially reported savings
The percentage change in total projected savings is shown for each provider. For those providers whose savings were decreased, it is shown in red, if increased it is shown in black.

We found substantial differences in the total savings identified and diversity of measures identified among service providers, which would appear to identify an opportunity for the industry to improve product quality and consistency. The wide variation in the results achieved by providers has been seen in other programs (Long 2008). As noted above, the ordering of the providers (A → G) is from highest to lowest based on their total savings identified (normalized on a kBtu/ft^{2}yr basis).
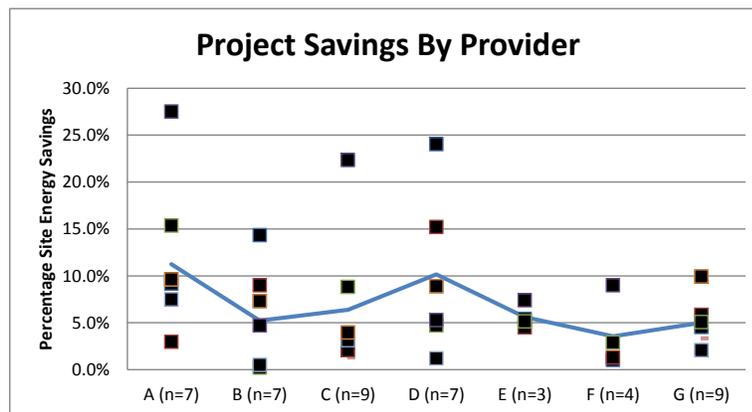

Figure C. Savings by project by provider
This graph shows the savings by project, as a percentage of total site energy, for each provider as well as the weighted average percentage savings (i.e. total of all savings for all their projects divided by total of all energy used at all their sites). The number in parentheses (e.g. n= 7) is the number of projects done by the provider.

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Total Savings kbtu/ft²

Figure D. Savings per square foot investigated for each provider.
This graph is a measure of each provider's total identified energy savings divide by the total square footage of their projects. The ordering of providers in this figure is used for all the other figures (i.e. provider C is the same in every example).

While it is inevitable that different projects will lead to different potential savings, the range seen in Figures C and D were a cause for concern and we investigated it further. There is a fairly wide variation (from 4 to 9) in the average number of measures identified per building by each provider as Figure E shows. The total number of measures includes some that were ultimately deleted from the final list of findings.

Measures per Building
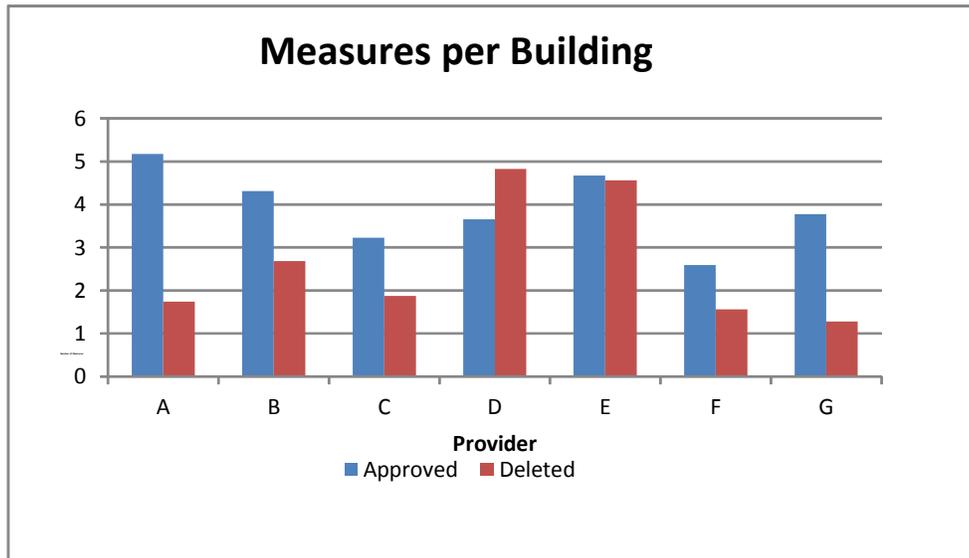
Figure E. Average number of measures identified per building
The number of measures per building as shown here differs slightly from the program total results because some providers reported multiple buildings in a single submission. This reduced the total number of reported findings (for example if the same measure applied to all buildings) and at the same time creates a higher number of reported findings per building

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There were three reasons that findings were deleted:
1. Additional investigation did not support the initial finding
2. The data and calculations provided in support of the finding did not pass the quality assurance process.
3. The finding was inconsistent with the owner's operating requirements indicating poor communication on the part of the provider, and the owner asked that the finding be deleted.

While the top two providers each identified about 7 measures per building (not all of which were approved), the most successful provider was able to follow through with sufficient data and supporting calculations to have 75% of their proposed measures approved, vs. 62% for the next provider. Two providers identified more measures per building than any others, between 8 and 9, but only half of them were able to be accepted by the program so the number approved were 3.7 and 4.7 respectively. Finally, the two providers with the lowest savings per building also identified the fewest measures per building (a total of 4 and 5 respectively).

The graphs below, Figures G, H, I and J, compare the major finding types by provider. The most successful providers identified the greatest diversity of measures, and, most importantly, more typical recommissioning measures than the others. These differences suggest the benefit of a rigorous EBCx certification program. The variation in retrofits and lighting measures was due to both the provider's general approach (some did not consider long payback items like new boilers to be within the scope of an existing building commissioning project) and the status of the buildings (only a limited number had any lighting opportunities).

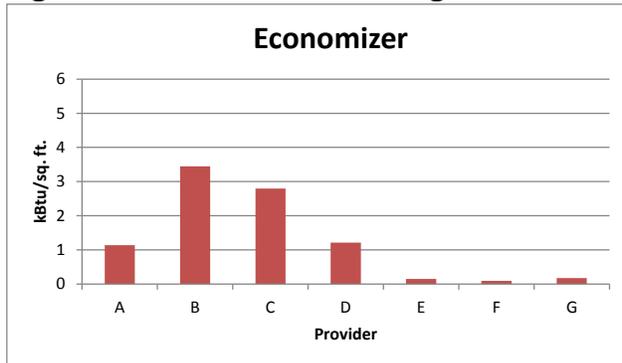**Figure G. Scheduling savings by provider**
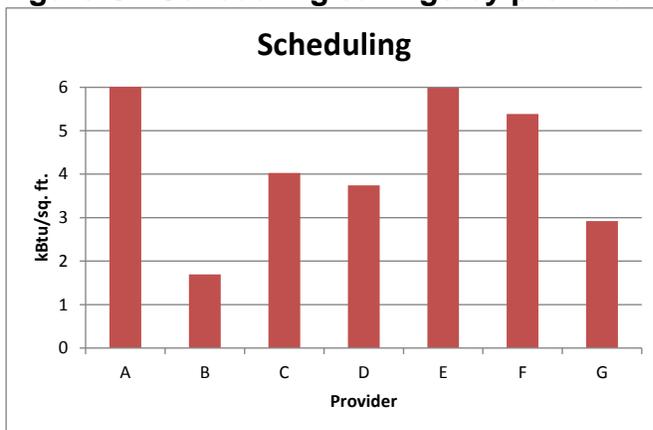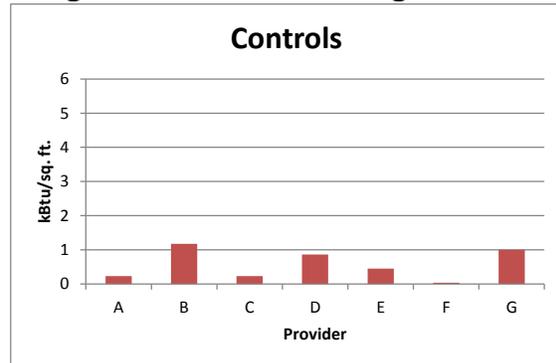

Figure H. Retrofit & lighting savings
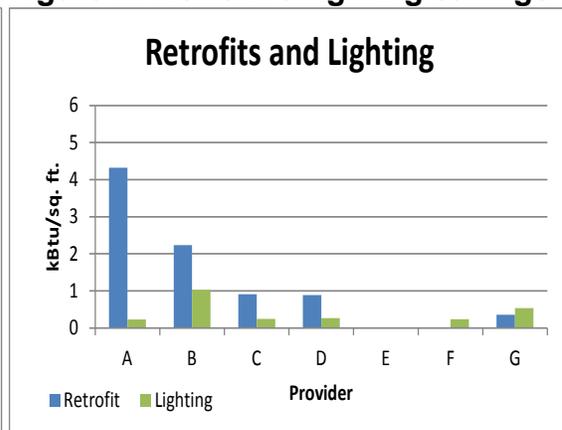
Scheduling includes: Time of day excessive; equipment enabled regardless of need; lighting on more hours than necessary; other equipment scheduling; zone setback sub optimal.
Retrofit and lighting category is made up of all retrofits including boilers, motors, heat recovery, lighting (including re-lamping at lower wattage), and controls upgrades.

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Figure H. Economizer savings

Economizer

Figure I. Controls savings

Controls

The unequal distribution of savings due to measures associated with economizer operations is seen as one of the strongest signs that not all providers were equally well prepared to do EBCx work. The vertical scale for reported savings is the same in all four figures. Controls includes adjustments and strategies including all reset schedules (HW, CHW, SAT, DSP), controls hunting, and all VFD issues

In addition to the results shown in the four figures above there were some savings from operations (no graph shown as these had the smallest savings) which are items that a facility staff can monitor and repair, such as leaking valves, bad sensors and deferred maintenance.

We categorize economizer operations and controls optimization as typical recommissioning measures. These two categories should be part of the core expertise of an EBCx provider. Yet we observe a difference of a range of a factor of ten among the providers when diagnosing these issues. Our contacts with the providers and knowledge of these sites convinced us that these were not due to the buildings, but rather reflected a wide range of competence. Given that economizer savings, for example, were the second most common finding in the program, and were reported in 70% of the buildings in the program, the fact that providers E, F and G reported savings of less than 0.2 kBtu/ft^{2}yr for them, while they averaged ten times that amount of savings, 2.0 kBtu/ft^{2}yr means that there were probably missed opportunities for additional savings. Similarly, the low number of controls related findings overall indicates that all the providers had difficulty with the highly technical analysis, not to mention the time, required to diagnose these opportunities.

We expected that each provider would have an individual style and areas of expertise, and we did not seek to change that. For example, one provider recommended low flow faucets aerators and shower heads whenever possible; no other provider ever made this recommendation. Another provider recommended reducing 32 W lamps to 28 W lamps at all sites; while this is a reasonable measure, it was proposed at several sites where there was already an ongoing lamp replacement project; the provider ignored this so as to propose greater savings. (The overstatement of savings was discovered in the project close meeting with the customer and the final report was adjusted.)

As part of our quality assurance program, our engineers revisited seven of the sites that had lower than expected savings to see if potential opportunities had not been overlooked. The total area of the seven sites was 2.8 million ft^2 (15% of the total program building area). Each of them had been investigated by a different provider. The follow up was an audit process, not a

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comprehensive re-investigation which sought opportunities that could be identified from analysis of trend data. It was intended to answer two questions: were there missed opportunities? And were there major omissions in the identification of savings? Additional energy savings opportunities were found at all sites, with an overall increase in the total savings at the seven sites from 4.6 kBtu/ft^{2}yr to 6.0 kBtu/ft^{2}yr (a 24% improvement). This review supports our conclusion that improved training and a certification process would be beneficial as there were clearly additional opportunities that were missed by each provider in the program.

Measures Selected for Implementation

The ultimate success of an Existing Building Commissioning program is actual energy saved, not a study that postulates impressive potential savings. By maintaining a close relationship with the customers, and being seen as their advocate and agent in this process, we have been able to continue to follow up on each project to encourage and facilitate the implementation of the identified measures. As noted above, the costs of the screening and investigation phases were paid for by the state's Department of Administration in exchange for each agency's commitment to implement all measures with a payback of three years or less. We were initially concerned that few measures with a payback over 3 years would be selected for implementation, but this has NOT turned out to be the case.

Overall, 78% of the measures identified, which account for 82% of the energy savings were selected by sites for implementation. There are plans to implement 88% of the measures with a payback of 3 years or less and 65% of those with a payback of 4 to 15 years. These results are shown in Figures J and K. Many sites would like to pursue longer payback measures but are not able to make the commitment due to uncertainty related to legislative funding, which is on a two-year cycle, not reluctance to pursue the measures identified in the investigations.
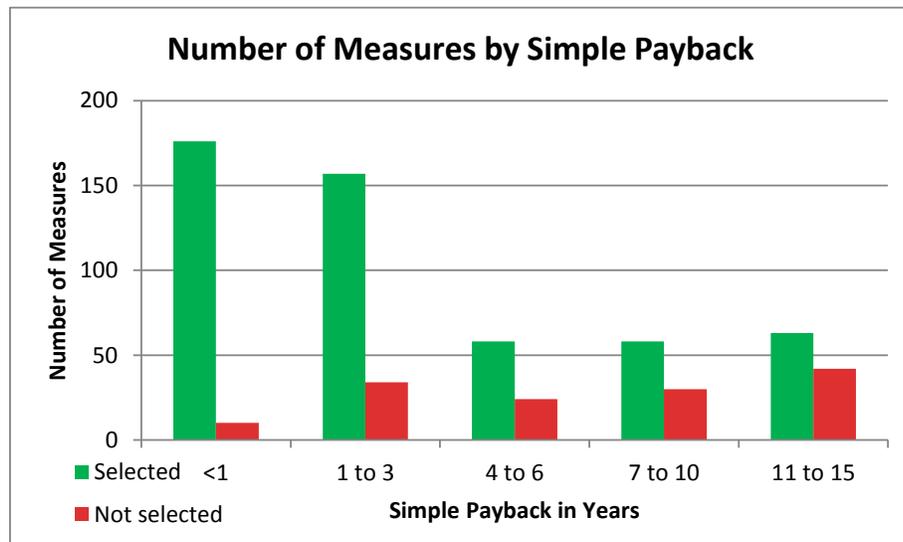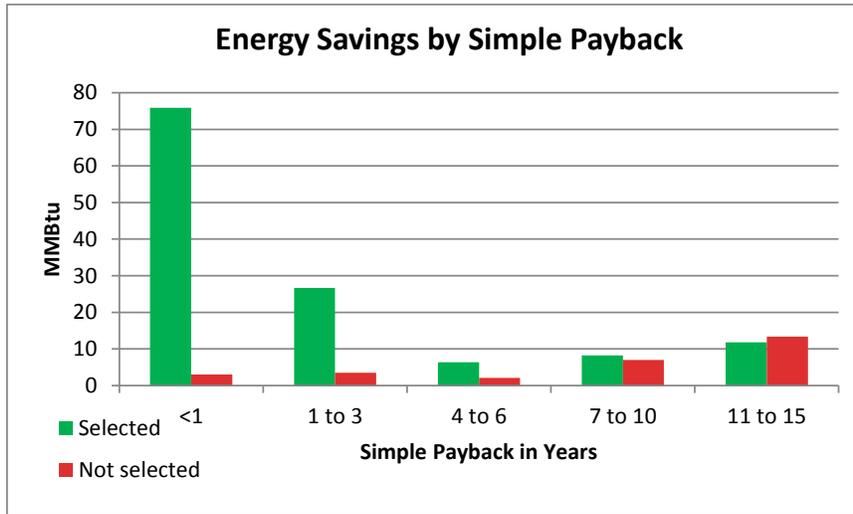

Figure J. Measures selected for implementation based on payback period

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Figure K. Energy savings of selected measures based on payback

The upper figure shows the number of measures and whether or not they have been selected by sites to be implemented arranged from shortest to longest payback. The lower figure shows the same measures, but the unit on the y axis is the total energy savings.

The number of measures selected for implementation may have been improved at those sites where there was a utility program in place for co-funding recommissioning studies (about 2/3 of the sites). For those sites receiving rebates, those funds, which are processed after completion of the study, have been applied towards the cost of implementing the energy saving opportunities.

Summary: Best practices and lessons learned

Looking at the four phases of the program, PBEEEP enjoyed a number of advantages over a standard utility program which, unfortunately, may not be easily replicated. For the initial application phase, prior to screening, we had access not only to addresses and emails of all potential buildings, we had internal backing from the state government, which has made energy use reduction a policy goal, and thus a responsibility of every state agency.

In the screening phase, we not only had direct contact information for the majority of the sites, we had a database that included building age, size and energy use information (B3 database). This allowed us to focus our efforts on those buildings that other studies had already identified as the best candidates for recommissioning.

In order to engage customers, and to speed the start of the program, CEE, as the program administrator, was allowed to perform the initial screening of all facilities. This saved time (since no contracting was involved), diminished risk and expectations (because all we offered was screening, a site was not committed to an investigation, and the program was not committed to proceed with an investigation that seemed unlikely to bear fruit). It also made the engineer who would manage the project, including the quality assurance reviews, to become acquainted with the facility and staff.

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The inclusion of a rigorous quality assurance program helped to assure that customers had confidence that forecast savings would be realized and thus have led to a high rate of measures selected for implementation. At the same time, our original program design would have worked better. ARRA funds were received early in the program and were a mixed blessing. As an assured source of funding, they made it much easier to convince sites to participate in the program, as they had no initial co-payment requirement. However, because the funds had to be spent rapidly (over a 30 month period) it forced us to run a large number of projects concurrently. This caused two problems: first we had intended to have each provider complete a project prior to being allowed to bid on a second project. The performance evaluation would become part of the RFP scoring criteria (not just lowest price) and providers would have better understood the level of effort expected by the program. Second, based on the results of the first projects, we would have limited the number of concurrent projects a given provider could undertake based on their past performance and available staff levels.

All of the providers overestimated their capacity to take on this work without additional training. The program provided one half day of mandatory individualized training to each provider prior to their first project. This training was less effective than we had hoped, primarily because the providers' did not think they needed any training; this realization only occurred once they were much further along in the projects. The quality assurance process includes extensive feedback; however this was not often utilized at a level commensurate with the effort to produce it.

The success of any program is completely dependent on the performance of the individual providers on each project. The intent of PBEEEP was for providers to perform the projects profitably and, by exhibiting excellence in their results, use the projects as a business development tool. We were surprised how often this was not the case. Rather than taking ownership of the relationship with the customer, several providers deferred communications, such as status updates, to the program administrator and thus failed to take advantage of a chance to build a customer relationship. This resulted in customer complaints of non-responsive providers and required program administrator mediation. While this has a negative impact on both the program and the provider, we did not develop any successful strategies to prevent its recurrence. Our recommendation would be for providers to utilize their sales and marketing staff throughout the project, not just in the customer acquisition phase.

We did observe improvement over time with most providers, generally following the feedback from our engineers' reviews of their results during the quality assurance phase. For these providers, this represents the successful achievement of the program's goal of improving the rigor and thoroughness of existing building commissioning projects in Minnesota.

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