Embedding Continuous Commissioning® in an Energy Efficiency Retrofit Program

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Abstract: his paper presents a case study where Continuous Commissioning®(CC®) [1], a process that optimizes the HVAC system operation and controls to reduce the building energy consumption and improve comfort, was embedded as one Energy Cost Reduction Measure (ECRM) in a $2.7 million energy efficiency program. The program covers four campuses and two administrative office buildings of a community college district, with a total conditioned area of 2.35 million square feet. Cumulative cost savings of over $1.7 million have been achieved since the start of the program in mid-2002. Savings as a direct result of the CC® efforts account for almost 2/3 of the total cost reduction. This paper discusses major commissioning activities for the central plants and building heating, ventilation, and air conditioning (HVAC) systems, as well as how deferred maintenance issues, key to the success of any commissioning project, were addressed and adminstered by the CC® engineer.

INTRODUCTION

Continuous Commissioning® (CC®) is a process that resolves operating problems; optimizes the HVAC system operation and controls to reduce building energy consumption and improve comfort based on current building conditions and requirements [1, 2, 3, 4, 5]. The CC® techniques developed at the Energy Systems Laboratory involve monitoring and solid engineering analysis of mechanical systems and occupant needs. The process achieves 10-25% whole building energy cost reduction with simple paybacks typically occurring in less than two years. It has been used primarily as a stand-alone process in over 300 buildings and central plants nationwide with measured savings in excess of $70 million since 1993.

Other than being a stand-alone process, there are three additional means to incorporate the CC® process:

1. As one ECRM within a retrofit project
2. Commissioning energy efficiency retrofits
3. CC® Leading Retrofit Process

The Energy Systems Laboratory has embedded CC® as a separate ECRM in two energy efficiency retrofit programs [1, 6, 7]. This paper presents the results from one of these programs.

PROGRAM OVERVIEW

In 2002, the Alamo Community College District (ACCD) in San Antonio, Texas initiated a $2.7 million project aimed at improving energy efficiency at its four major campuses and two administrative office buildings. The four campuses are San Antonio College (SAC), St. Philips College (SPC), Palo Alto College (PAC), and St. Philips College Southwest Campus. The two administrative office buildings are located in downtown San Antonio. The total conditioned space included in this program is 2,350,000 square feet.

Major ECRMs include retrofiting T-12 lighting with magnetic ballasts to T-8 lamps and electronic ballasts, Continuous Commissioning® of all buildings and central plants, cooling tower replacement at the SPC campus, building automation system (BAS) upgrades, roof-top package unit replacements, variable air flow and variable chilled water pumping, and other HVAC system replacements and renovations. The estimated total annual savings are $450,000, roughly 21% of the base year energy costs. Figure 1 shows the breakout of estimated annual cost savings by category. The majority of the expected savings come from CC®, which accounts for 62%, followed by lighting retrofits (22%) and the remaining upgrades and renovations (16%). Because of the dominance of CC® in total savings and its relatively short paybacks (3 years in this case), some capital intensive upgrades with relatively long paybacks were made possible, while still keeping the overall project payback at 5.4 years.

[1] The terms Continuous Commissioning and CC are registered trade marks of the Energy Systems Laboratory, Texas Engineering Experiment Station, Texas A&M University System.

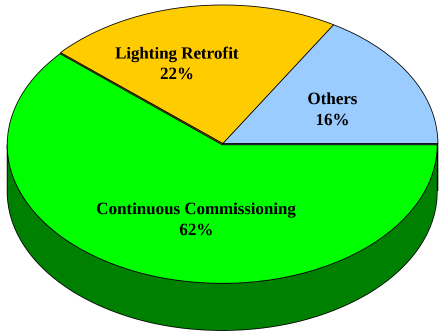

Fig.1: A Breakout of Estimated Annual Energy Cost Savings at ACCD.

The CC® ECRM

During the initial energy assessment process, major CC® opportunities at each site were identified. These measures were prioritized during the detailed CC® plan development phase. The CC® engineers began implementation of the CC® measures at the three main campuses (SAC, SPC, and PAC) during the summer of 2002. This is a logical choice because these three campuses represent 75% of total floor area and have a modern BAS at each site, allowing many control strategies to be implemented quickly to help reduce the summer peak electric demand, as well as electricity and gas consumption. These CC® activities are outlined below with a brief description of each measure.

Optimize Chiller Control

Criteria and set points for chiller start/stops were fine-tuned to improve the staging sequences. Reset schedules for the chilled water supply temperature set points were introduced to improve part load chiller efficiency.

Optimize Boiler Control

Boiler start/stop sequence and existing hot water supply temperature set point reset schedules were refined to minimize simultaneous heating and cooling.

Chilled/Hot Water Loop Delta Pressure Resets

All three campuses have primary-secondary loop configurations at the chiller plants, with constant speed chilled water pumps on the primary loop and variable frequency drives (VFDs) on the secondary pump motors. The VFDs on the secondary loop pumps are modulated to maintain loop delta pressure (ΔP). The ΔP set points used to be constant and relatively high for normal operation. In one of the campuses, the ΔP set point was so high (30 psi) that it drove five secondary pumps (75 horsepower each) to full speed in the middle of the winter (one chiller has to be operated year round due to the lack of economizer capabilities in some buildings). Reducing and resetting the ΔP set point saved a significant amount of pumping power. This measure also helped reduce the simultaneous heating and cooling due to over pressurization of the chilled water loops with the high ΔP set point that lifted some of the "closed" valves at the air handling units (AHUs).

Most of the building chilled water pumps are also equipped with VFDs. Their ΔP set points were also adjusted and reset based on load conditions.

Similarly, ΔP reset schedules were implemented on the campus hot water loops and building hot water loops for all three campuses.

AHU Temperature Resets

Supply air temperature and cold/hot deck temperature set points were reset to reduce simultaneous heating and cooling energy consumption. This measure was implemented in both variable air volume and constant air volume AHUs.

AHU Duct Static Pressure Resets

By resetting the AHU duct static pressure set points, significant fan power reductions were achieved. The Library Building at SAC is a good example. The duct static pressure set point used to be so high (3.5 inches of water column) that it drove all three supply air fans to full speed in the middle of the winter. One of the main supply air ducts literally came apart, apparently due to over-pressurization. By reducing and resetting the duct static pressure set point, it was estimated that approximately 150 kW of peak fan power demand was saved in that building alone.

Like the water loop ΔP reset, this measure also helped reduce simultaneous heating and cooling by reducing unnecessary air mixing and reheat at the terminal boxes.

Improved Economizer Operation

The range and set points of economizer operations for the single-duct AHUs were optimized to take advantage of free cooling. Since the supply air temperature set points were reset based on outside air temperature, the economizer set points were chosen to follow the same reset schedule.

Sensor Calibration and Repairs

Key sensors, such as the outside air temperature sensor, AHU cold and hot deck temperature sensors, duct static pressure sensors, and water ΔP sensors, were verified and calibrated when necessary. In some cases, the sensors were relocated to obtain better readings.

Improved Start/Stop Schedules

Room by room surveys were performed to determine the building occupancy schedules, especially during the evenings and weekends. AHU start/stop schedules were optimized accordingly to minimize the runtime.

VAV Box Calibration

Minimum and maximum VAV box airflow settings were evaluated and properly adjusted based on current space function and occupancy schedules. Along the way, broken pneumatic and DDC box controllers were replaced or repaired and recalibrated.

Repair Malfunctioning Devices

The CC® engineer generated a list of deferred maintenance items, and prioritized the items based on their impacts on building comfort and system efficiency. Typical items include broken VFDs, leaky valves, inoperable dampers, dirty coils, etc. Most of these items fall into the deferred maintenance category, and they were dealt with separately, as discussed in the next section - Deferred Maintenance.

Deferred Maintenance

One of the many challenges facing CC® and recommissioning engineers is the handling of deferred maintenance issues. To some extent, the success of the program depends on resolving the deferred maintenance issues and restoring the funtionality of the control devices. Therefore, it is critical to obtain cooperation from the building owner to resolve these issues in a timely fashion. Any delay in resolving these issues will not only continue to cost the owner in wasting extra dollars, but also result in unrealized/lost savings opportunities since many of those issues directly impact system performance. Sometimes these issues can also lead to comfort problems. Our experience suggests that many operators are capable of performing most of those deferred maintenance items, provided they are given enough time and reasonable amount of resources to accomplish the task. Unfortunately, the lack of funding are often cited as the main reason that things are not fixed when they break.

Based on the initial survey findings, CC® engineers estimated the amount of resources needed to fix the deferred maintenance items. We then approached and convinced the owner to allocate $140,000 to the CC® cost to deal with these items, which raised the payback of CC® from 2.5 years to 3.0 years. However, fixing these "broken" devices allowed the CC® work to progress faster.

After consulting with the owner and operations personnel, suitable mechanical, electrical and controls sub-contractors were selected to work on those deferred maintenance issues. The CC® engineer assumed the responsibility of creating the work order for each item, touring the job site with the sub-contractors, and obtaining quotes from the sub-contractors. After the work orders were issued, the CC® engineer oversaw the repair work and field verified the work performed before approving the invoices from the sub-contractors.

The process worked quite well, with all repair work completed on schedule.

Results

By the summer of 2003, most of the CC® measures had been implemented at SAC, SPC, and PAC campuses, while the rest of the ECRMs were just getting started after the completion of the design and bidding processes. Therefore, it is possible to separately evaluate the savings that are largely attributed to the CC® efforts.

Using monthly utility bills, a baseline was established for each campus based on the 2001-2002 fiscal year. Energy models were developed for each energy cost, i.e., electric energy, demand, and natural gas. Based on the pre-CC energy consumption models, actual savings of $315,566 were achieved from June 2002 through September 2003. This represents 105% of the original estimated commissioning savings for these three campuses for the same time period, even though the CC® activities were on going throughout much of this period.

By May 2006, the cumulative electricity, electric demand, and gas savings at these three campuses totaled over $1,700,000 (See Figure 2). This includes the savings from Continuous Commissioning® and other retrofits.
Following the completion of the project, the CC® engineer continues to monitor the savings and work with the ACCD staff to fine-tune the operations of the buildings, i.e., the "continuous" portion of Continuous Commissioning®.

SUMMARY

Continuous Commissioning® has been successfully applied as one of the ECRMs for a $2.7 million energy efficiency program at a community college district. Analysis showed over $1.7 million of cumulative cost savings since June 2002. Major commissioning activities for the central plant and building HVAC systems are discussed in the paper. One unique aspect of this program is a special fund set up to address the issue of deferred maintenance, with the CC® engineers designated to adminster the repair work that falls into the deferred maintenance category.

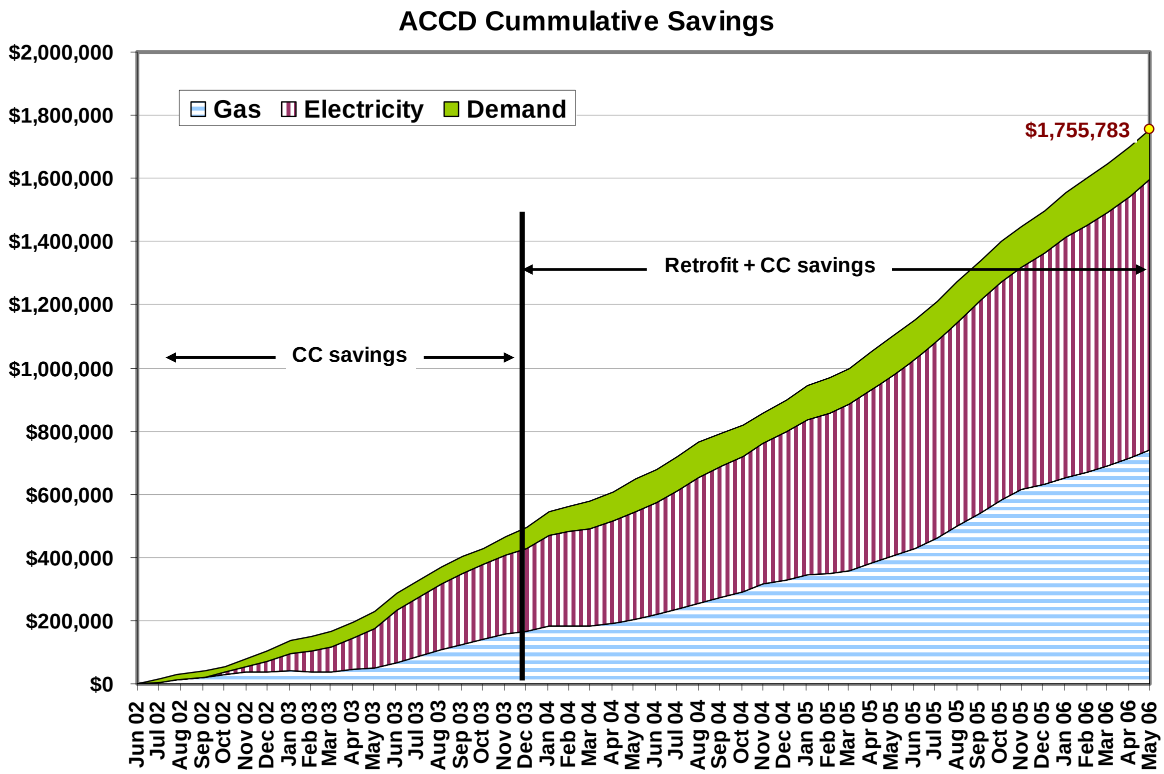

Fig.2. Cumulative Energy Cost Savings at ACCD (Based on Actual Utility Rates)

ACKNOWLEDGEMENTS

The authors would like to thank ACCD and its staff for assistance provided during the CC® process. We would specially like to thank Val Santos, Director of Facilities and Lalo Gomez, Assistant Director of Facilities for Operations, and their staff, David Wissman, Lynn Teiner, Steve Rodriguez, and James Gonzales.

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