A Competitively Bid Retrocommissioning Project In the County of Los Angeles - A Model Process?

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Synopsis

A partnership comprised of the County of Los Angeles' Internal Services Department, the Southern California Edison Company, and the Southern California Gas Company commenced a two-year HVAC system retrocommissioning project in 2004 in order to achieve energy savings and electricity demand reduction. The project, funded by public goods charges, was approved by the California Public Utilities Commission, administered by the two participating utilities and implemented by all of the partners.

After considering various procurement methods, the partnership issued a request for proposal with a work scope that emphasized the HVAC retrocommissioning process and specified the buildings to be retrocommissioned. Thus, unlike more traditional utility commissioning programs, the project contractor was not required to demonstrate energy savings on any building before it would be retrocommissioned.

The selection of the successful bidder was based on criteria including price, experience, qualifications, and availability. A fixed price contract was awarded for the retrocommissioning work scope and a change order process was established to allow implementation of identified system repairs, upgrades, and energy efficiency measures.

This paper describes the major challenges and, ultimately, successes of the partners' unique process that was used to retrocommission 11 facilities maintained and operated by the Internal Services Department. It also details the project benefits, including energy savings, and costs of optimizing HVAC system performance by retrocommissioning. The authors also consider how this process may be modified to serve as a model for retrocommissioning.

About the Authors

R. Anthony "Tony" Pierce is a registered Mechanical Engineer in California and works for Southern California Edison's Design & Engineering Services group. He has been involved with the California Commissioning Collaborative since its inception and promotes building commissioning through field demonstration projects and training activities. Tony's role on the County of Los Angeles partnership project was to provide technical support, including preparation of the request for proposal work scope and defining the implementation process for retrocommissioning measures.

Narendra Amarnani was the project manager for the County of Los Angeles' Internal Services Department, Energy Management Division on this retrocommissioning project. Mr. Amarnani also co-authored the original program technical proposal that was subsequently approved by the California Public Utilities Commission. He also co-authored the project request for proposal. Narendra is a registered Mechanical Engineer in California and earned a graduate degree from Cal Poly University, Pomona. He is a Certified Energy Manager, a LEED Accredited Professional, and a Certified Energy Plan Examiner. His engineering specialties have included solar thermal power cogeneration, building HVAC sciences, and energy engineering consulting.

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The fourth member of the project team was our retrocommissioning service provider, EMC Engineers, Inc. Led by their project manager, Tom Poeling, EMC's team included in-house personnel and a sizable cast of knowledgeable subcontractors.

The authors truly believe that the project successes are a direct result of all the partners and contractors pulling together.

Defining the Retrocommissioning Procurement Process

Under the auspices of the California Public Utilities Commission (CPUC), the Southern California Edison Company (SCE), the Southern California Gas Company (SCG) and the County of Los Angeles (County) entered into a two-year program partnership commencing in 2004 that included building retrocommissioning (RCx) as a program element. The filed program approved by the CPUC included electricity and natural gas energy savings, and electricity demand savings goals. It was left to the partnership to determine how RCx services would be procured to achieve those goals.

Since the County had already accomplished significant lighting retrofits, and would complete still more under another element of the 2004-2005 partnership program, the RCx project would target the County's heating, ventilating, and air conditioning (HVAC) systems. The County desired to accomplish the following objectives through the RCx project:

- Benchmark the HVAC systems' optimized performance
- Manage sustainable, optimized HVAC system performance utilizing the County's enterprise energy management information systems (EEMIS)
- Train building technicians on the retrocommissioning process and the new HVAC system operating parameters
- Provide a single document resource for the County's Operations & Maintenance staff
- Meet or exceed the energy and demand savings goals filed with the CPUC

Initially, the Partnership team's approach to the procurement process placed the responsibility for achieving the RCx goals largely on the bidding contractor. This procurement method would place the burden of defining a retrocommissioning process and an energy savings calculation methodology on each bidder. Each bidder would then be required to describe their process for realizing the energy and demand savings goals.

However, after deliberation amongst the Partnership, it was decided that the request for proposal (RFP) would include a technical work scope describing the required RCx process. Additionally, the successful RCx provider would be required to estimate the energy savings resulting from any implemented optimization measures, but would not be accountable for achieving the project savings goals.

As a result, the issued RFP included the Partnership's RCx process and identified other project requirements for reference. The RFP listed eight building groups, with a total of twenty-four buildings that were selected by the County as likely to be good RCx candidates. The building selection process targeted facilities that had demonstrated an historically high energy utilization index. Additional factors that influenced the selection of project buildings included the status of the EEMIS integration and whether or not lighting and HVAC retrofits had been completed.

The RFP required each bidder to deliver RCx services according to the following process:

- HVAC system performance benchmarking
- Retrocommissioning project planning
- Prefunctional testing (PFT)
- PFT energy efficiency measure (EEM) implementation
- Functional performance testing (FPT)
- FPT EEM implementation
- Training
- Final reporting

Bidders were invited to submit proposals for one or more, or all, of the eight building groups. The Partnership evaluated all bids based on the criteria of technical approach, project schedule, team strength and experience, relevant RCx experience, and price. Bids were then scored and ranked by building group. The Partnership elected to withhold one third of the RCx program element budget for implementation of optimization measures during the RCx process. As a result, two building groups were awarded based on the top-ranked firms' prices.

The two awarded groups included one office building and nine courthouses within the County of Los Angeles. During the last month of the two-year program, another courthouse was added to the RCx project with funds remaining from other program elements.

The following sections describe the key activities in the Partnership's RCx process.

RCx Process Activities

Benchmarking Phase

The RCx provider was furnished with facility as-built documents, weather data tapes, and electric and natural gas bills for the most recent three years. This information was used to establish the pre-RCx benchmark performance information.

Spreadsheets and Cal-Arch, an energy benchmarking software program, tools were then used to determine energy density metrics (kilowatt-hours per square foot (kWh/sf), therms, and British Thermal Units per square foot (kBtu/sf)) for the facilities under the contract. These energy density calculations established the basis for savings estimates and validated the County's energy usage index (EUI) values for the selected buildings.

The RCx provider submitted an initial benchmarking report documenting the calculation methodology and each building's EUI. Additional system-level benchmarks, based on eQUEST model simulations, were developed in the final phase and examples of chiller and boiler benchmarking graphs are provided in the reports as illustrated by Charts 1 and 2.

Chart 1: System-Level Benchmark for Chiller Demand

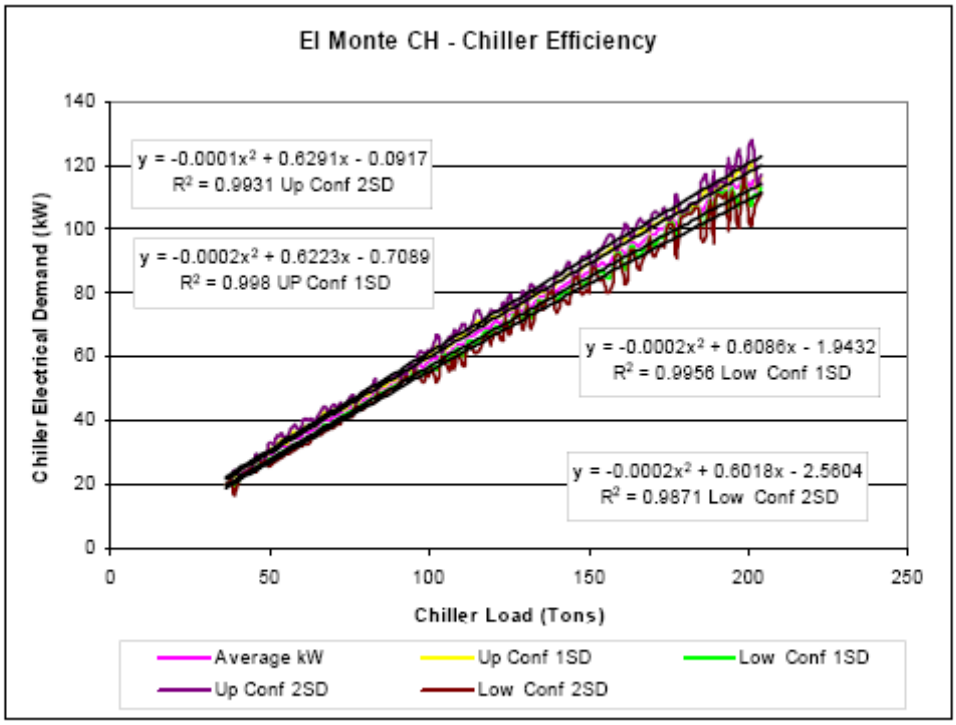


Figure 4-20. Chiller Electrical Demand vs. Cooling Load – Representation with Equations

Chart 2: System-Level Benchmark for Boiler Load

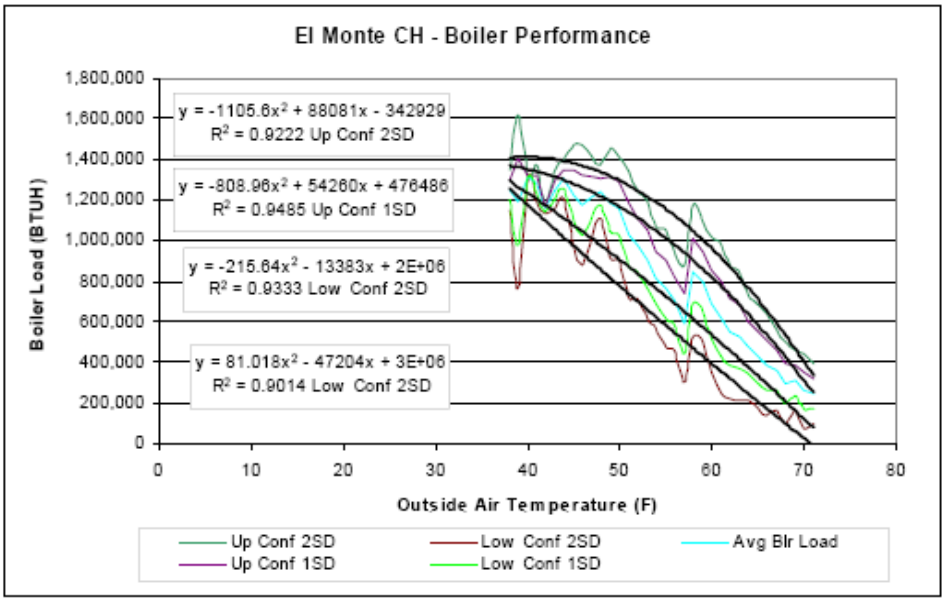


Figure 4-23. Boiler Load Performance – Representation with Equations

RCx Planning

Once the RCx contract was in place, the County arranged for the respective building refrigeration mechanics to be interviewed by the RCx provider. During this phase, the RCx provider visited each site with the mechanics and received an orientation on the maintenance and operations aspects and issues of the building HVAC systems.

The County technicians shared their system knowledge, history of modification and trouble issues, and expected solutions with the RCx Provider. Armed with available as-builts, preventive maintenance logs, and occupant complaint logs, the RCx provider audited each facility to identify and document the current operational and maintenance status of the HVAC system. A planning report was submitted for each building containing comprehensive building information and deficiencies observed during this initial building visit. An example of a section of one building's deficiency log is illustrated in Figure 1. These planning reports identified the project timeline information while confirming that all activities required in the Partnership's RCx process were included.

Figure 1: Sample Deficiency Logs

11	11/15/2005	Software Code	The building is operating 24/7 because when the occupied schedules turn on, they can't turn off due to a programming error. It appears that the building has been operating 24/7 since Dec 8, 2003. It's a mistake in the schedules' code.	Fix programming error.	The error was fixed, and the program was tested by overriding the building clock to simulate morning startup.	11/15/2005
12	11/15/2005	AHU-1	The economizer flag was "on" even though the OA enthalpy was greater than the RA enthalpy. This appears to be related to both the OA enthalpy flag not being in place and the Economizer flag being locked in the off position.	Fix programming error so that the economizer operation is automatic.	Programming error was fixed.	11/15/2005
13	11/15/2005	AHU 3	AHU-3 has a time delay on econ operation set to 240 seconds while the other 2 AHUs is set to 0 sec.	Time delays should be consistent across AHUs.	12/7: ETI set the delay for all AHUs to 240 seconds	12/7/2005
14	11/16/2005	Cooling Towers	Chiller 1 is tied to CT-2 (East). Chiller 2 is tied to CT-1 (West). When chiller 1 was enabled, CT-2 turned on and ran at full speed. However, the VFD for CT-2 was in hand, and the display was dark, indicating that the VFD does not work. The CT-1 fan was running at minimum speed. However, the VFD for CT-1 appeared to be working since the display screen turned on, but the readings were not consistent with actual cooling tower operation (they were not reliable). It appears that both cooling towers are activated together regardless of which chiller is running. The fan motors themselves are activated by the chillers. The VFDs appear to be both controlled by the CWS temperature, which the setpoint is set on the VFD itself. Note that both disconnects (CT-1 and CT-2) turn off the CT-1 VFD.	It appears that the wiring from the disconnect to each VFD needs to be checked. Both VFDs may need to be replaced.	ISD-BEAS will address	
15	11/16/2005	Cooling Plant	There are no alarms for the cooling plant.	Basic alarms should be programmed to notify BEAS whether equipment has failed to operate or switchover.	12/14: Alarm points were added, programmed, tested and passed.	12/7/2005

The County used the deficiency lists from the RCx planning reports to dispatch its centrally-managed maintenance mechanics to resolve the listed deficiencies in anticipation of the prefunctional testing.

Prefunctional Testing

During the prefunctional phase major field activities were performed to identify specific operations of each HVAC system. The RCx provider, along with their subcontractor teams, performed a thorough examination including the following:

- Review of existing sequence of operations
- Verification of the County's EEMIS trend logs
- Calibration of controls components

- Visual assessment of HVAC system equipment
- Boiler tune-ups
- Diagnostic airflow and temperature measurements
- Hydronic system balancing
- Modeling baseline energy usage of the HVAC system
- Development of scope of work and cost proposals for recommended optimization measures, or energy efficiency measures (EEM)

The baseline energy modeling was accomplished using an hourly energy simulation program called eQUEST (Quick Energy Simulation Tool), which is based upon the DOE-2.2 calculation engine. The energy models were calibrated with the buildings' historical EUI and field-verified data points.

Most of the intrusive field activities were performed during the unoccupied period to minimize the impact on the building occupants. In this manner, the buildings continued to perform normally as scheduled. The County coordinated the RCx provider's efforts with building and maintenance and operations (M&O) staff. The County dispatched M&O mechanics to attend to maintenance and repair issues discovered during the course of the field activities.

Each EEM was also simulated using the eQUEST program to generate estimated operational energy and cost savings. The EEMs were included in a prefunctional report that was submitted to the Partnership for review and approval.

EEM Implementation

The Partnership reviewed the prefunctional report for accuracy and relevancy, weighing the costs and benefits of recommended EEMs. Selected EEMs were then implemented by one of two methods. In some cases, the County used in-house resources to implement a measure. In other cases, a change order was issued to the RCx provider enabling them to implement the measure.

Although the Partnership, in formulating its RCx process, had indicated that it may elect to choose another vendor for the implementation of measures, it was decided to use the RCx provider as the general contractor for the sake of timely delivery. Thus, the RCx contract was amended by change order to authorize the work to implement EEMs using funds that had been reserved for that purpose.

During this phase the County's M&O and Energy Management Division staff implemented many EEMs recommended by the RCx provider. Most of these measures involved HVAC control setpoint and schedule changes.

Other recommendations, many involving control programming changes, were contracted out to the RCx provider who subcontracted much of the work to local mechanical and controls contractors. Commissioning of the implemented EEMs and demonstration to County staff was included in the new work scope.

It should be noted that this phase was initially anticipated, as described in the project RFP, to follow the functional performance testing. However, given the use of the energy modeling technique adopted to identify EEM benefits, the team elected to also list and implement measures after the PFT phase.

Upon implementation of this first group of EEMs, functional tests were performed as described below. The functional performance tests phase would identify more optimization measures that would be implemented after review and acceptance by the Partnership.

Functional Performance Testing

While EEMs were being implemented following the prefunctional test phase, the Partnership approved the functional performance test (FPT) procedures for all facilities, including EEMs previously implemented. The RCx provider began functional testing of the HVAC systems during the unoccupied hours with the assistance of their controls subcontractors. During this phase more deficiencies and optimization measures, though fewer in number, were discovered and reported. These EEMs were subsequently dealt with using internal M&O staff or through change orders directed to the RCx provider. Ultimately, all the change order related measures were successfully commissioned and demonstrated to County M&O or Energy Management Division group. Functional performance test logs were submitted by the RCx provider.

With the completion of functional performance tests and the implementation of the final group of selected EEMs, major field operations subsided. The RCx provider then monitored the optimized system, with emphasis on the EEMs, by remotely monitoring the County's Enterprise Energy Management Information System (EEMIS).

RCx Final Report

The RCx provider submitted final reports on each building documenting the optimized state of the HVAC system and providing tools for sustained operations. The tools that the County now has at its disposal include building performance benchmarks, optimized sequences of control, and programmed EEMIS trend logs.

Each report includes an Executive Summary that specifies the cost and energy savings of individual, implemented EEMs, a brief narrative of the program, and entities who contributed to this retrocommissioning project. Additionally, trend logs using the County's EEMIS over the internet can now substantiate the successful operation of EEMs in the optimized state. Chart 3 provides an example of the trend log data now available now to the County on its EEMIS.

Training Manual

As stipulated in the project RFP, the RCx provider prepared an RCx Training Manual to be used primarily by the County's Operations & Maintenance (O&M) staff. The Training Manual is to support the M&O staff by providing a compilation of documents in one place.

The contents of the Manual include an overview of the retrocommissioned HVAC systems and a description of the optimization measures implemented during the RCx project. The measure descriptions include background information and, in some cases, the reasoning behind the measures.

The Manual also describes the verification process used to ensure that the implemented measures were commissioned to provide sustainable results. Verification of measure performance included using the County's EEMIS to track various parameters.

Maintenance procedures that should keep the HVAC systems running efficiently, final control sequence of operations, and blank Functional Performance Test forms are included to facilitate recommissioning by the O&M staff.

The RCx provider also provided classroom and on-site training to the O&M mechanics to familiarize them with the new HVAC measures, the Training Manual, and other documents developed during the RCx project.

Retrocommissioning Results

The long-term goal of this retrocommissioning project was to implement a systematic approach to identify and implement opportunities to improve the County's building operations. Implemented opportunities should optimize HVAC system performance in maintaining thermal comfort, indoor air quality, and energy efficiency.

The project administration and engineering departments for Southern California Edison, Southern California Gas Company, and the County's O&M and Energy Management staff teamed up with the RCx provider to correct deficiencies found during the survey and implement optimized measures following the prefunctional tests and functional performance tests.

Optimized HVAC Operations

It is important to note that the correction of mechanical and controls programming deficiencies allowed the system to be operated optimally by compressing equipment run schedules and utilizing temperature reset schedules. Chillers and boiler pumps were locked out based on outside air or return air temperatures and economizers were reactivated.

Chart 3, excerpted from the project report, illustrates the performance of a system's hot deck reset control sequence.

Chart 3: Trend Log Verifying Hot Deck Reset Sequence

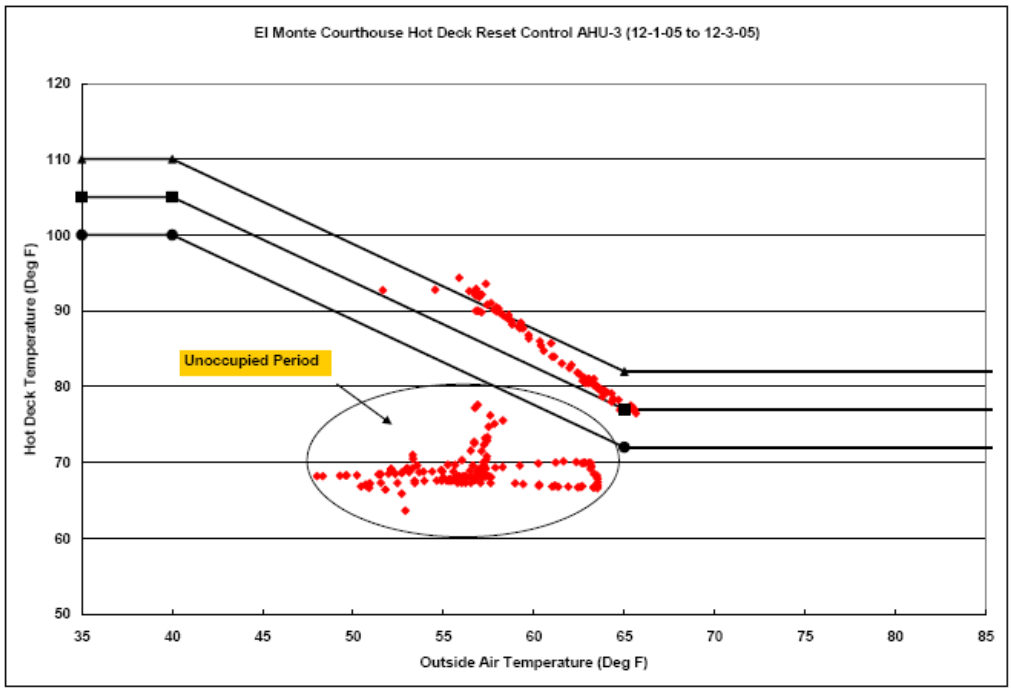


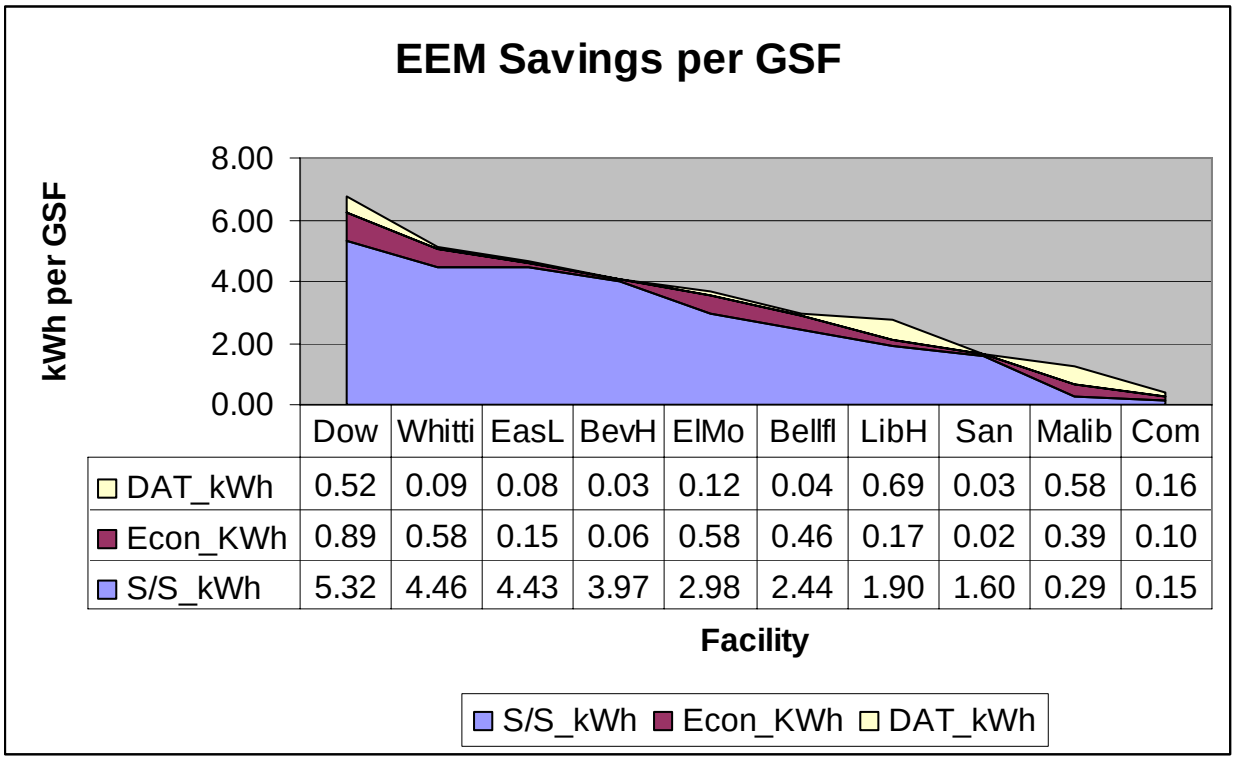
Figure 3 -9. AHU-3 Hot Deck Reset Control Trend Data

New Energy Efficiency Measures

Many of the EEMs involved enabling system features properly to optimize performance and realize energy savings. The most common control measures implemented include chiller start/stop, air handling unit (AHU) start/stop, boiler pump start/stop, hot water temperature reset, cooling deck supply air temperature reset, hot deck supply air temperature reset, and economizer sequence based on outside air and/or return air temperatures. Additionally, boiler tune-ups were completed at each building.

As seen in the Chart 4, the largest savings resulted from chiller, AHU, and boiler pump start/stop. The economizer control settings and the change in the discharge temperature of cold and hot deck also provided additional savings. In 80% of the facilities an optimized start/stop schedule is estimated to be saving, on average, 2.71 kWh per gross square foot (gsf) of building area per year. The economizer operation provides an additional annual savings of 0.28 kWh per gsf and discharge air reset sequence for cold deck and hot deck combined can be expected to deliver up to 0.11 kWh per gsf.

Chart 4: Annual EEM kWh Savings per GSF for Start/Stop, Economizer, and Discharge Air Temperature Reset

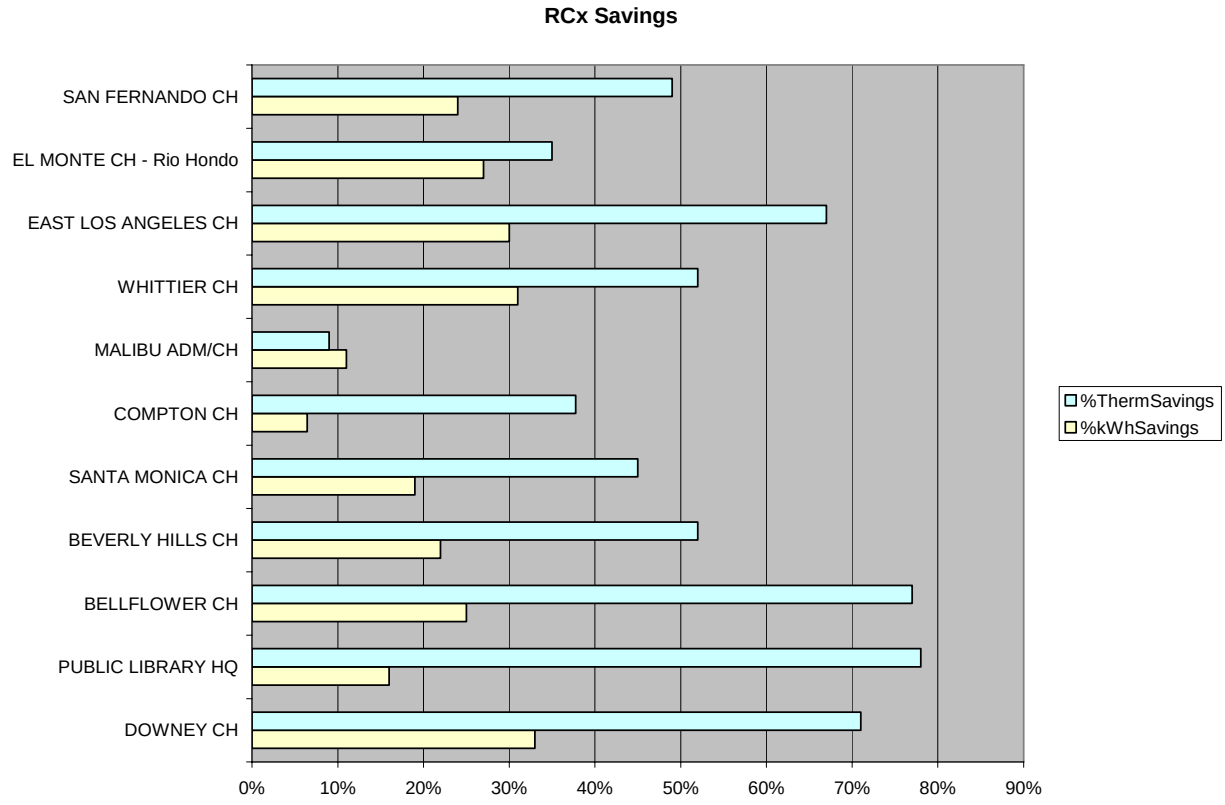


RCx Energy and Cost Savings

Not discounting the fact that with RCx there are occupant comfort and O&M benefits, gains in operational efficiency are measurable. The annual combined electricity and natural gas savings range that has been reported in industry ranges from $0.10/gsf through $1.10/gsf. It is also reported that 80% of facilities can deliver $0.35/gsf and $0.18/gsf in electricity and natural gas savings, respectively. Similarly, 80% of the facilities running at current optimized state may deliver up to 3.82 kWh/gsf and 0.21 therms/gsf, respectively.

Chart 5 illustrates the optimized, modeled energy savings of 22% kWh and 52% therms on average, for each of the County buildings included in the RCx project.

Chart 5: RCx Savings per GSF – all EEMs

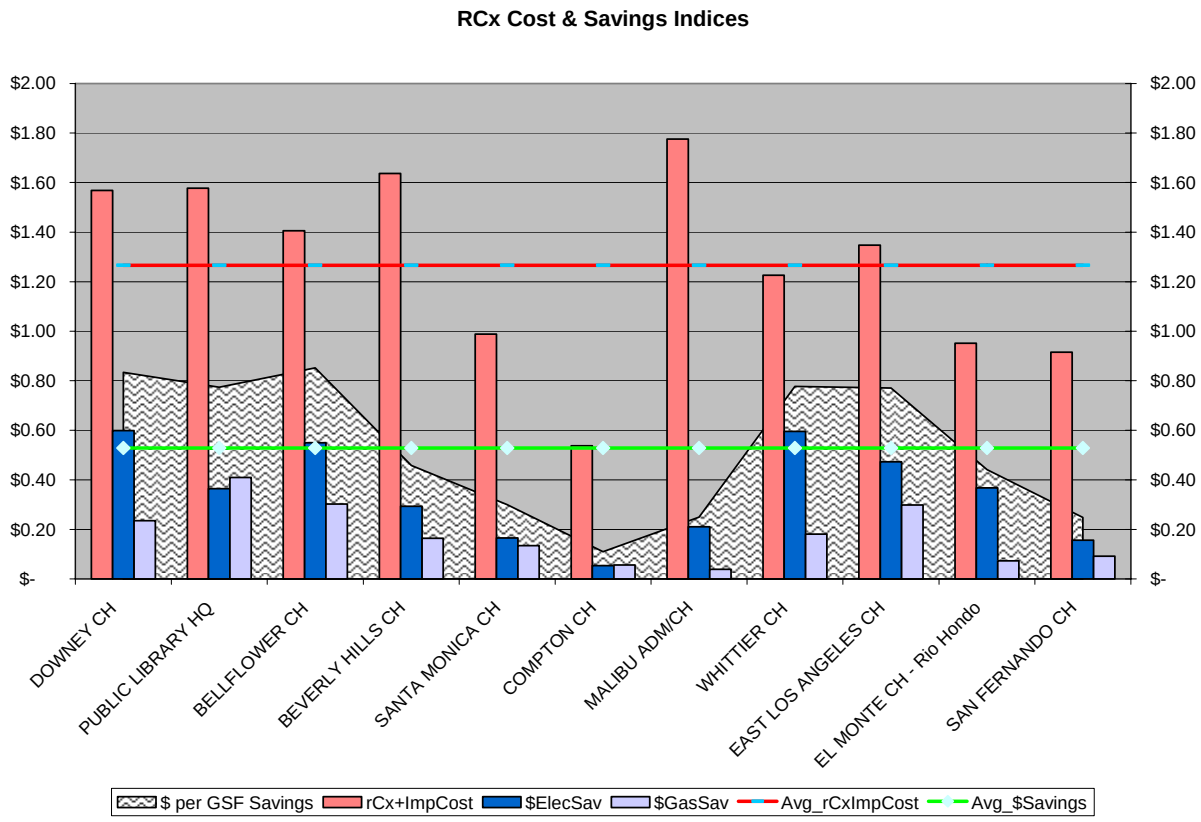


The cost involved in getting the HVAC systems to operate optimally includes the RCx provider fees, the measure implementation costs, and the owner's in-house cost of supporting the RCx process. Chart 6 illustrates the RCx provider and measure implementation costs for each building. Note that these costs range from $0.54/gsf to $1.78/gsf.

Most of the maintenance and repair work related to correcting system deficiencies, as well as much of the building engineer operator level controls work, was accomplished by the County's O&M staff.

Estimated energy savings are expected to range from $0.11/gsf to $0.85/gsf. The average cost (including retrocommissioning service, EEM implementation by contractor, and County O&M services) and savings are observed to be $1.27/gsf and $0.573gsf, respectively. The simple payback is estimated to be 3.1 years.

Chart 6: RCx Cost and Savings per GSF



A wide variation in energy savings was observed for the portfolio of project buildings. The greatest savings, 5.32 kWh/gsf, was achieved where malfunctioning variable frequency drives (VFD) resulted in the drives being placed in manual operation at full speed.

The smallest savings, 0.15 kWh/gsf, were estimated for the building where existing control sequences functioned rather smoothly. It must be noted that optimized Start/Stop requires rather close watch on the systems operations and expedient response by building mechanics to resolve malfunctioning equipment or components.

Conclusion

The Partnership's principal objective of realized optimized HVAC system performance at the eleven project buildings was deemed highly successful. The retrocommissioning process was implemented with minimal disruption to the building occupants and deficiencies were corrected at many of the buildings resulting in improved thermal comfort and indoor air quality.

Additionally, the program energy savings goals were dramatically exceeded. The electricity savings bested the goal by over 70% and the natural gas savings exceeded the goal by over 25%.

Importantly, these energy savings were realized without stipulating that the RCx provider deliver specific savings estimates. More commonly, utility programs require that the provider estimate savings prior to receiving authorization to proceed with the RCx process.

By specifying a general RCx process, in lieu of stipulated savings targets, the Partnership was able to select a retrocommissioning provider from a large number of competitive bids. Through this procurement method, the RCx provider selection could be based upon many criteria, of which price was but one. The result was that a qualified, experienced provider was awarded the project at a competitive, market cost.

Key to this procurement method is the active participation of a capable building owner. In the Partnership project, the County contributed numerous resources, including knowledgeable building technicians, energy management system staff, and energy efficiency project management and engineering staff. This support, coupled with the County's prior investment in a system-wide enterprise energy management information system, was an enormous factor in the success of the project.

In order for other building owners to replicate the results obtained by the Partnership, they must consider themselves as active participants in the RCx process. Whether in-house or contracted maintenance staff is employed, those individuals must be engaged in the RCx process from its commencement.

The building owner should also require that the RCx provider deliver a report of all findings and recommended measures. While many RCx efforts seek to differentiate between commissioning measures and retrofit or repair measures, the County project required that all measures would be listed along with the estimated benefits and costs of each. In this way, measures could be prioritized by cost and benefit-to-cost ratio. Then the change order process could be used with the project funds set aside for this purpose to implement the most cost-effective, affordable measures. The information on measures not implemented during the RCx project could be used for future project planning.

As a result of the thorough, systematic HVAC retrocommissioning process implemented for the Partnership project, the County now has the tools it needs to achieve sustainable, optimized HVAC system performance.