RCx Case Studies: The Good, The Bad,[1] The GREAT, Plus A Path Forward Action Plan Based on Expanded Training!

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ABSTRACT

The RCx process is well conceived. The program has the potential to identify and accurately document real savings in real time. In addition to being well conceived, the RCx procedures are well defined and continue to evolve. This evolution has resulted in a higher efficiency relative to "getting energy projects deployed and validated effectively." This paper describes the RCx process as it has evolved. As importantly, it will discuss the importance of training, at all levels, as a key component of RCx success (and, in fact, the success of any energy efficiency or energy conservation activity).

Program Background, *The Good*

Retro commissioning (RCx) is a systematic process for: (a) identifying less-than-optimal performance in an existing facility's equipment, lighting, control and process/comfort systems; then (b) making necessary adjustments to promote energy savings.

Whereas typical energy efficiency retrofitting involves replacing outdated equipment, RCx focuses on improving the efficiency of what is already in place. Retro-commissioning projects can produce an average savings of 5-15% of total facility energy costs. These upgrades typically pay for themselves, in energy savings alone, in as little as two years (sometimes even less).

Eligible energy conservation measures (ECMs) can range in complexity from simply adjusting lighting control schedules to creating complex control algorithms which automatically adjust systems operations. Although the idea sounds great, successful program implementation relies on a myriad of personnel; all of whom must be trained in the unglamorous and often tedious tasks associated with retro-commissioning. In considering a successful RCx process, ask the question:

1. Who identifies the changes;
2. Who makes the changes;
3. What manager allocates time; priority and budget to implement these changes; and,
4. What "user" accepts the changes as "positive"

Each one of the above involves not only technical or financial or managerial expertise, but also involves a respect for, and appreciation of, the process involved in actually achieving persistent energy savings.

[1] "BAD" is used as a metaphor to the Clint Eastwood movie of fame. This portion of the paper dramatizes the complexities and ambiguities, which are a natural extension an implemented RCx program.

As an example of the challenge, let's look at item #4, above and consider the user. In today's society everyone wants to be "green", but whether layperson or professional, unless specifically trained in energy efficiency and conservation, "green" is more closely associated with solar panels or wind turbines. So the "user" in most commercial spaces or industrial activies, recognizes only comfort or production as his/her priority. He or she may turn off a light, or begrudgingly allow the room temperature to be set as high as 78degrees or, heaven forbid, allow an energy engineer to alter his/her production control sequences. So it takes training to understand that a well thought out RCx plan, can affect all aspects of corporate success. Let's frame all of the above against the framework of the current evolution of the RCx program.

Utility incentive programs started over 25 years ago. But even with almost a quarter century of focus on energy-related rebates or incentives, many working level technicians and mid/high level managers don't associate any activity (i.e. any capital or maintenance project or purchase) as containing "imbedded energy" and therefore probably being eligible for incentive funding. So, yes, some customers are recognizing that they can contact their account managers to determine eligibility for an incentive. When they do, the Utilities are starting to recognize the lack of training and awareness at all levels. So, at least for the RCx program, the Utility can deploy an engineer (Utility sub consultant[2]) to perform a brief, site evaluation and score the building according to several key metrics including size, age, location, and energy consumption. If determined to be eligible, a team of engineers is selected by the utility sub consultant to perform an in-depth[3] site audit including complete equipment inventory and a baseline of energy consumption.

In the beginning of PG&E's RCx program deployment, there were seven deliverables required of the third party engineering team (called Providers). These deliverables were defined and in seven activity levels:

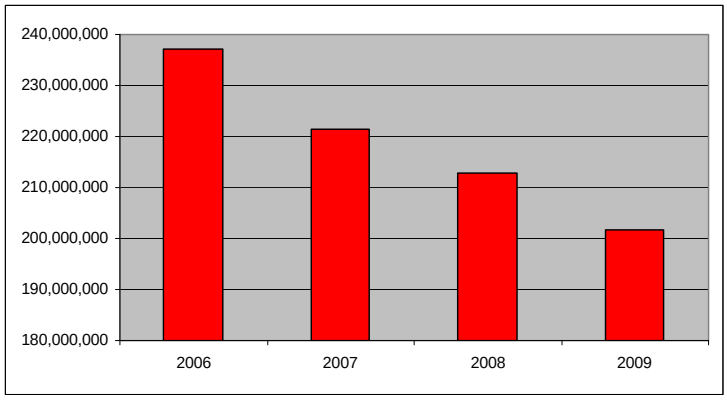
1. A Initiation Plan
2. A Measurement and Verification (M&V) Plan to calculate savings
3. An Analysis and Investigation Report with comprehensive site inventory, analysis, and calculations to estimate energy savings
4. A Pre-implementation Report outlining all ECMs recommended by the provider and documenting the measurement and verification requirements to substantiate savings.
5. A Post-implementation Report documenting all completed measures and detailed energy consumption measured values (i.e. "before" and "after" measurement and verification.
6. A Training Report for the customer which describes the process associated with the program as well as the technical and financial justification and activities required to implement the specific retro commissioning activities.
7. A list of other projects identified for application to PG&E's Retrofit Program (for additional savings not covered under the RCx program)

Case Study, *The Good*

An RCx plan was recently deployed for a major customer. This customer has an annual energy use of 212,890,045 kWh and 3,789,804. With an annual energy bill of over $16million,

[2] Currently PG&E, for instance, employs Newcomb Anderson McCormick
[3] "in depth" is discussed in further discussed in the section of this paper entitled "bad"

this is certainly a major energy user and a major candidate for RCx. As importantly, the history (pre RCx and current RCx) indicates significant attention to energy use. This is substantiated by an active energy users group and the 4-year annual electric consumption history in the adjacent graph. As seen in the adjacent graph, overall use is down over 20,000,000 kWh per year. Gas use over the same period is down over 1million therms.



To date the most successful projects occurred in Phase 1 and Phase 3 of the RCx program deployment. In both cases, the customers utilized literally hundreds of fans in its high performance clean rooms. It was reasoned that the air delivery equipment providing ventilation to several of the main "lines" was a major energy user, and that manufacturing needs could be met by tuning the fans, while also reducing filter face velocity (FFV). In this case, RCx measurements were employed to both:

- Validate pre and post energy usage; and
- Validate that adequate ventilation rates were provided

As stated above, it is believed that initial acceptance of the project, and ultimate project success was achieved becasue upper and middle level management had begun to recognize energy efficiency (with or without Utility incentives) as a critical priority of the company. All staff, from upper level, to working line, were partially trained (let's call it "sensitized") to recognize that a key metric to company success involved saving 4,000,000 kWh of electricity per year. Recognizing this, there was easier acceptance of the process for adjustment to generally lower air distribution via lowering the filter face velocity (FFV) of hundreds of fans (and ultimately re-balancing the fans). Even with that training and recognition, the effort involved first documenting a baseline air balance of the Line 1 and Line 4 services areas (for Phase 1) and eventually in the line 5 service area (for Phase 2). After the base line was established, an air balancing contractor systematically tuned each fan filter unit, air handler, and other myriad of air delivery equipment to lower FFV to the rate of 78 feet per minute (fpm). Once this was completed, final airflow rates were measured (in CFM/BHP and motor amperage) and compared to baseline values. In each case, the rebalancing of air delivery resulted in lower energy consumption by the air handling equipment. This, of course, involved budgeting, staffing, and subcontracting.

In summary, documented savings (pre and post use) was as follows:

Phase 1 savings: 811,801 kWh
Phase 3 savings: 552,064 kWh

The RCx procedures were also championed as a natural extension of good practices (i.e. for clean room reliability and safety) in addition to energy savings and cost savings. As importantly, the success of Phase 1, and the subsequent RCx training (which quantified the

savings and reliability issues) led to relatively easy implementation of Phase 2 (for line 5). The resultant incentive checks suggest that, eventually, all of the customers "lines" will undergo this process.

Case Study and Program Background, *The Bad*

At its core, RCx is really just an energy audit, but with "pre" and "post" measurements in place of energy project calculations. Since energy audits began in the 1980's most users, managers and facilities technicians at least understand the concept of an energy audit. So initial training in the RCx process, can work best by comparing the conventional energy audit to the RCx program as follows:

PROGRAM ELEMENT	ENERGY AUDIT	RCx PROGRAM
1	Identify Project(s)	Identify Project(s) *and metering req'ts*
2	Calculate Savings	Take baseline use measurements
3	Implement Project	Implement Project
3	Verify Installation	Take "post" use measurements to document real savings
4	Receive Incentive	Receive Incentive

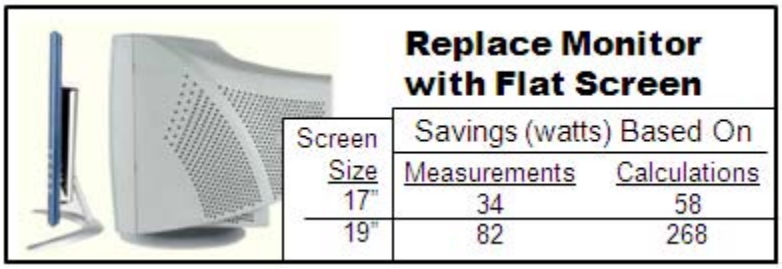
In this case study the seven elements of RCx made for a cumbersome process. As challenging as this cumbersome process, three major issues presented themselves at both the working level and the management level:

1. Measured savings vs. Calculated Savings (without on-going training, there can be an elevated expectation of savings, and a lack of understanding of the complex procedures required to measure savings).
2. Secondary and tertiary systems effects (particularly at the user level, without training, there is a natural response to any project to say: *"just leave me alone. I don't want to be too hot, too cold, and I fear that your activities will affect my main production focus"*.
3. Level of effort vs. in-depth site audit (even the Utility program directors and the Utility program manager, without training, can become removed from the working level efforts, details and challenges associated with achieving persistent energy savings through RCx. Even the relatively "simple" fan speed reduction project involved significant time, significant measurements and significant documentation).

Calculated Savings, *The Bad*

Engineering efforts, by definition, thrive on details. Therefore, it stands to reason that the best engineering effort would rely on accurate measurements. In the real world of customer satisfaction, the size of the incentive check is a big reason for implementing any energy project. And, in the real world, measured savings are often smaller than calculated savings. This is best dramatized by Figure 1 which shows that, even for a simple project, calculations which can rely on rated or nameplate information, can show savings as much as 4 times that of measured savings.

Figure 1

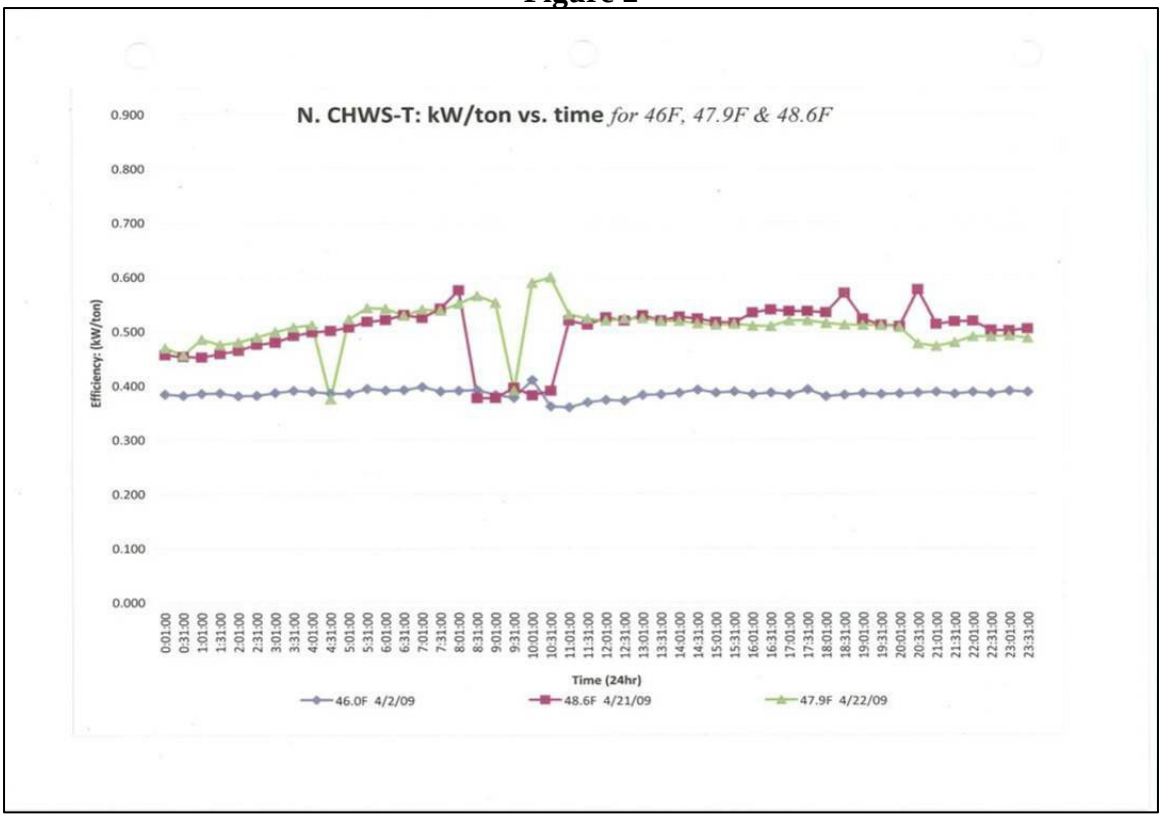


Case Study Secondary and Tertiary Effects, *The Bad*

The Phase 2 effort involved a number of projects. The relatively straightforward project to raise chilled water temperature dramatizes the complexity of real world M&V. This customer's chiller plant was comprised of 12 chillers, totaling over 20,000 tons total capacity. The initial analysis involved reviews of manufacturer's chiller profiles to validate that chiller consumption is reduced with increasing chilled water supply temperature (i.e. increasing chilled water supply temperature from 42F to 49F). Tests were also conducted to ensure that the site supported by the chiller plant could function as needed. After extensive measurements and data acquisition, the results of measured chilled water reset are provided in Figure 2.

As can be seen in Figure 2, the test data actually shows that increasing chilled water temperature INCREASES energy consumption. Likewise, the kW/ton is significantly lower than that predicted by the M'fg. Therefore, this extensive data, M&V results in more questions than answers.

Figure 2



Case Study Level of Effort vs. In Depth Energy Audit: *The Bad*

The overall Phase 2 effort ultimately involved M&V of four (4) projects; including the chilled water reset temperature project discussed above. The fee for this effort was $0.02 (2 cents) per sf. In this case, the converts to 8 person weeks of available time, even at below-industry billing rates. Standard commissioning and MBCx[4] efforts are budgeted at as much as $1.50/sf. When framed against the need for detail, the complex validation requirements, and the need to expand training to all levels, this results in a potentially underfunded activity.

Program Background, *The Great*

Clear improvements in the program are evident by observing RCx changes in 2009 and 2010. These changes occurred through the Utility program managers listening to Administrator, Customer, and Provider input. As a result RCx requirements were reduced from seven, to four, and ultimately to three required deliverables; summarized as follows:

in January 2009, Reduction to 4 Deliverables	In January 2010, Reduction to 3 Deliverables
1. An Initiation Report (combination of the aforementioned RCx Plan, M&V Plan, and Analysis and Investigation Report) 2. An RCx Findings Report (formerly the Pre-implementation Report) 3. An RCx Implementation Report (formerly the Post-implementation Report) 4. A Training Report	1. An Investigation Report (combination of the aforementioned Initiation Report and Findings Report) 2. A Verification Report (formerly the Implementation Report) 3. A training report

All of these changes were created in an effort to maximize savings and minimize service costs. And, as such, they must be recognized as great improvements. However, the "last frontier" and by far of greatest need, is the need of an expanded focus on training.

Path Forward Action Plan

Training as a key element of long term program success. One large aspect of the above is that the training associated with RCx projects (or in fact, any energy efficiency or energy conservation project) is viewed, by the utility as a discreet activity. But training can and should be the "thread" that ties together the entire process and all levels of management, user and facilities. Recognizing training as a continuum, throughout the process of retro-commissioning (and energy efficiency project implementation) will:

- **Aide the utility:** in being viewed as the "go to" provider of solutions that impact energy, but are also a valuable part of production, comfort, cost containment and "green".
- **Aide management:** in viewing RCx (and any energy program) as a way to tear down barriers to interdepartmental collaboration; and

[4] Monitoring Based Commissioning

- **Aide facilities technicians** as being recognized as a company asset who can create improvements to production, safety, comfort and cost containment, while also moving the company at large towards a “greener” image; and
- **Aide the end user** in recognizing that working “green” and living “green” is something that is directly under user control, and contributes to the company bottom line and the image of the company as “green”.