Lean Retro-Commissioning: Improving the Effectiveness of the Utility Sponsored Retro-Commissioning Process

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ABSTRACT

Retro-commissioning (RCx) can be largely defined as the process of improving the operational and maintenance aspects of an existing building. As these types of measures are typically embedded in the behavior and sequences of daily building operation, determining areas of improvement requires a systematic process of analysis, testing, implementation, and verification. There are several models utilized across the industry that range from a "find-and-fix" approach that focuses on identifying opportunities and immediately fixing them to a detailed analysis approach centered on quantifying the measureable impacts of each opportunity prior to implementing the measure. This paper is aimed at achieving a structured middle-ground between these two approaches that integrates the "find-and-fix" approach into the traditional process of detailed analysis followed by implementation. Details provided in the following sections are from the perspective of a utility sponsored RCx program that requires a level of rigor in quantifying the impacts necessary for resource planning. While such an approach may have been implemented on an ad-hoc basis in many utility sponsored RCx projects, this paper offers a structured method that improvises the traditional process to align with the end goal of effective yet verifiable and timely implementation. Some of the key benefits attributable to our approach and elaborated in the following sections of the paper are increased project momentum, increased certainty of project completion, a reduction in project completion time by about 50% and more involvement in implementation from all the stake holders.

Background

Operational and maintenance (O&M) improvements have been performed within buildings since buildings were initially constructed. However, the process of systematically identifying, quantifying, and implementing building improvements was not effectively adopted until the rise in popularity of energy efficiency programs in the late 1980's. The traditional utility sponsored RCx process has generally involved identifying, analyzing and implementing energy conservation measures in large commercial and industrial facilities. Innovations evolving from experience and continuous improvement by professionals involved in the field have constantly contributed to increasing the effectiveness of the RCx process.

A "find and fix" approach may be the most efficient means of achieving operational and maintenance (O&M) improvements. However, quantifying measure level impacts with certainty using this approach is more difficult. This makes it a challenge to demonstrate and verify results to regulators and resource providers.

While the goals and objectives for the utility sponsored RCx process vary depending on the needs of the participant, our paper aims at contributing to this evolution by presenting an alternate approach that yields the same level of technical rigor as the traditional approach

through a structural change that facilitates faster implementation. The recommendations in this paper are relevant to public utility sponsored RCx projects that allocate a fixed budget to achieve persistent and verifiable energy savings as the end goal.

Definition of Key Team Members

- **Customer.** Customer, as referred to in this paper, is the Owner or Owner's representative of the building being retro-commissioned.
- **RCx project manager/administrator.** A project manager or a project management team member assigned by the resource provider to administer and supervise an RCx project.
- **RCx service provider (RSP).** A professional agent with demonstrated experience in providing RCx services.

Traditional RCx Approach

The traditional utility sponsored RCx process involves a four step systematic approach to achieving energy savings by identifying and implementing low-cost and no-cost energy savings measures, and ensuring their persistence.[1] The traditional process involves the following stages:

Planning Phase

The purpose of the Planning Phase is to perform a high-level review of low-cost and no-cost energy savings opportunities. The Planning Phase consists of developing a preliminary study to guide stakeholders in assessing the order of magnitude of savings potential at the facility. This phase helps in prioritizing the measures for further investigation as well as establishing a determination of the level of project savings available to justify the project analysis expense. The RSP usually leads this process.

Investigation Phase

The Investigation Phase builds upon the Planning Phase. If the planning phase study determines a viable project, a detailed investigation is performed where the building systems are functionally tested for performance, data is analyzed, measures are identified, recommendations are populated and prioritized for implementation, and savings are quantified. The Investigation Phase also involves documenting the baseline parameters and accounting for interaction between the measures. A verification plan, describing the expected results from the Implementation Phase is outlined, included in the Investigation Phase summary report and provided to the customer. The RSP works with the customer in this phase.

[1] Although the Building Commissioning Association, in its paper, defines EBCx or RCx as including capital intensive facility improvement measures, the projects in this paper, while identifying capital measures, focused solely on low-cost and no-cost measures (Miller & Santhanakrishnan 2008).

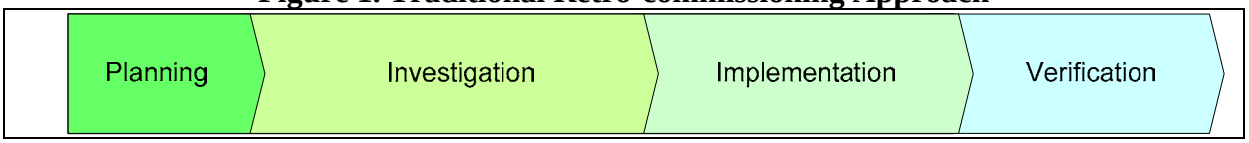
Implementation Phase

Upon completion of the Investigation Phase, the scope of work contained in the investigation summary report is provided to the customer's implementation team. Work conducted in this phase entails implementation activities followed by testing to confirm proper operation. Depending on the level of budget available, the RSP may be involved by the customer to guide the implementation team and provide technical support. The customer may chose to implement the measures using in-house or external contractors.

Verification Phase

Upon completion of the Implementation Phase, the RSP revisits the site and conducts M&V activities to ensure proper implementation of each of the identified measures. In this phase, measure implementation is verified against the expectations outlined in the verification plan.

Figure 1. Traditional Retro-commissioning Approach



As shown in Figure 1, the traditional RCx process is sequential in nature where each process follows the previous. The traditional RCx process follows a systematic structure where a solid foundation is built at each phase. Such a structure affords an organized and well-documented process throughout each phase resulting in well-analyzed and quantified savings for each measure rather than relying on changes in utility bills. Most large scale utilities and resource providers have deferred to the traditional approach as it provides confidence at a resolution necessary for resource planning, in the measure level of impacts achieved.

Integrated RCx Approach

While the goal of both the traditional and the integrated approaches are to identify, quantify, implement, and verify low-cost and no-cost energy conservation opportunities, the integrated RCx approach aims at structurally changing the process to align with the end goal of verifiable and timely implementation. Such an approach mitigates the risk of changing customer priorities throughout the progress of the entire project.

However, the integrated RCx approach specified here affords the creation of tools, deliverables and resources to support a systematic parallel flow of processes. Table 1 shows a sample comparison of deliverables used in the two processes discussed in this paper.

Using these tools, deliverables and resources, single measures or groups of measures can be documented and accepted/rejected by the customer through a collaborative process involving all stakeholders. In this approach, integrating the Investigation and Implementation Phases allows customers to obtain a priority list of measures early on in the process that encourages them to implement fixes as soon as a set of individual measures have been identified, baseline recorded and approved for implementation. As a result of this change, the RCx team stays

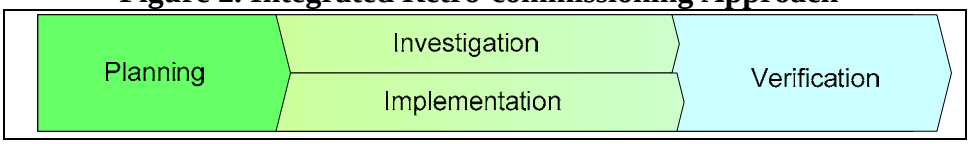
constantly motivated to maintain project momentum attributable mainly to the sense of accomplishment realized from incremental progress they experience at regular intervals.

The integrated approach is structured to flow in parallel, where the Investigation and Implementation Phases occur simultaneously (see Figure 2).

Table 1. Comparison of Deliverables in the two Approaches

Traditional Approach	Integrated Approach
Planning Report with the following: - Includes a high level list of measures	Planning Report with the following: - Includes a high level list of measures
Investigation Report with the following: - One comprehensive prioritized list of measures - Detailed baseline and recommended information - Preliminary M&V Plan	No Investigation Report(s) Selection form that groups measures together based on priority Simplified documentation for each measure documentation for each measure that is utilized from the start of the project to completion: This section includes the following: - Baseline information - Methodology to perform savings analysis - M&V Plan
Verification Report that includes a summary of the findings and final savings	Verification Report that includes a summary of the findings and final savings

Figure 2. Integrated Retro-commissioning Approach



The integrated approach follows a three-step process described below:

Planning Phase

Similar to the traditional RCx process, the Planning Phase in the integrated approach is intended to assess the viability of the project. The goal is still to mitigate the risk associated with the project's cost-effectiveness goals. The Planning Phase in the integrated approach is slightly longer in time. The increased length of time results because one of the tasks of the Investigation Phase - populating a preliminary priority list of measures to be implemented early on in the process, is escalated to this phase. The value arises from the fact that the customer can choose to implement a set of quantifiable measures immediately after the Planning Phase instead of having to wait. The preliminary list of measures will comprise measures whose baselines are recordable (for e.g: equipment scheduling) within the budget/time of the Planning Phase. If the project is proven viable, the customer evaluates the feasibility of each of the measures and makes initial measure selections. When preparing the prioritized list of measures, the RSP will account for interactions between the measures to prevent unforeseen consequences in building systems' operation.

Integrated Investigation and Implementation Phase

Upon completion of the Planning Phase, the customer proceeds with implementation in batches of measures, prioritized based on their collective ease of implementation, availability of immediate funding, effect of interaction on other measures etc. This starts with a first set of measures recommended in the Planning Phase that have a recorded baseline.

Simultaneously, the RSP begins their detailed investigation work on alternative sets of measures that were deferred for additional investigation in the Planning Phase. Every batch of measures is presented to the customer for evaluation and acceptance before detailed investigation. For measures selected by the customer, the RSP begins with documenting baseline information for the purpose of energy savings determinations. This ensures that adequate operational data has been collected before a measure is implemented. Once the baseline is well documented, problems well defined, interactions accounted for and recommendations in place, the customer will be allowed to implement the measures immediately while the RSP moves on to the next batch of measures. This process will continue until all cost-effective measures are identified and implemented.

The customer will still remain responsible for the overall completion of measure implementation. The RSP will remain involved during measure implementation by providing technical support and advice.

While the customer remains engaged in implementing the measures, the RSP and the program administrator collaborate to ensure that the quantification of impacts is consistent with the engineering principles and the level of rigor expected by the program administrator.

Verification Phase

Similar to the traditional approach, upon completion of the Implementation Phase, M&V activities are conducted, final measure savings are quantified and presented as a part of the Verification Phase summary report.

Key Differences between the Two Approaches

Figure 3 presents a comparative chart showing the key differences in the team members involved in each of the approaches.

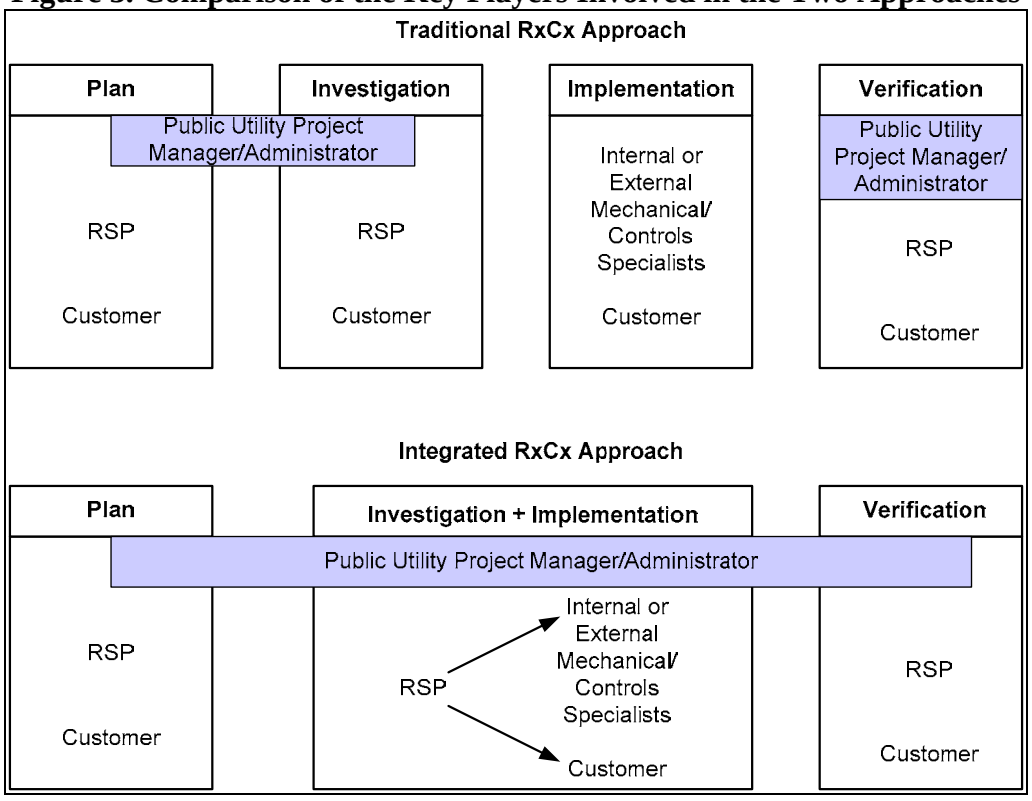
In the traditional approach, the Planning, Investigation and Verification Phases are largely carried out by the RSP. The customer facilitates information flow and resources to support the RSP in their activities and carries the responsibility of implementing the measures recommended by the RSP in the Implementation Phase. The customer may choose to use his/her internal resources or hire a contractor to help the RSP in the Investigation Phase and complete the implementation of the recommended measures. The RCx project manager/administrator is largely involved in supervising the progress of the Planning, Investigation and the Verification Phases. Involvement of the RSP, while strongly recommended, is usually a choice made by the customer in the Implementation Phase.

On the other hand, in the integrated approach, while the key player involvement in the Planning and Verification Phases are largely similar, the structure of the integrated Investigation and Implementation Phase facilitates technical support from the RSP to the customer.

Best Practice Considerations

In executing the integrated approach, similar to the traditional approach, it is essential to begin by establishing standardized program protocols and defining roles and responsibilities. These tasks include field visits, functional testing, data collection, spot measurements, data analysis, measure pricing, measure implementation and coordination between the investigation and implementation activities.

Figure 3. Comparison of the Key Players Involved in the Two Approaches



It is recommended that the RSP's scope of work, defined at the outset of the project, include technical support to the customer during the measure implementation. This should include support for troubleshooting measure implementation, assistance in negotiating reasonable costs from vendors, and clarifying scope of work to vendors as needed.

The RCx project manager/administrator should be responsible for training the RSPs on the process and communicating the value of the integrated approach clearly to the customer in making sure all or any of the concerns are addressed.

The traditional and the integrated approaches have their own unique merits. The integrated approach builds upon the traditional approach by creating a sequential process of investigating a measure, implementing it and then moving on to the next measure.

Some of the salient features of integrated approach are as follows:

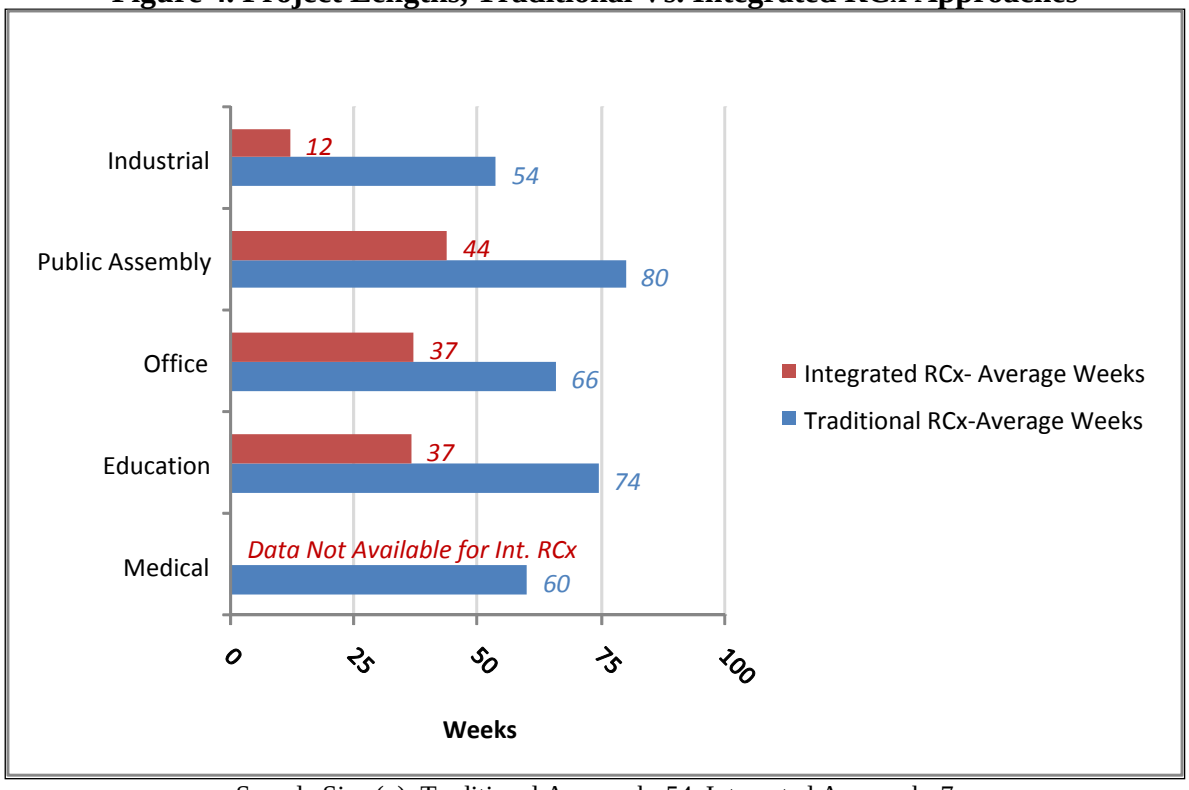
- Mitigates the risk of changing customer priorities associated with the completion of the Implementation Phase after a costly Investigation Phase through quick, value-added and systematic progress from plan to implementation

- Since the expectation is to make incremental progress, the Owner is only required to incur incremental expenses that results in immediate value.
- Structurally integrates technical support by involving RSP during implementation, promoting more involved participation by all stake holders
- Some of the costs incurred in quantifying, preparing and reviewing the investigation report are diverted towards supporting actual implementation activities in the field.
- Eliminates the time gap between the end of investigation and the beginning of implementation thus reducing the overall lead time.
- Other ACEEE publications recommend using binding program agreements between the customer and the sponsoring utility as an essential alternative in mitigating the risk associated with the potential that the customer will not implement the measures identified (Moore, et al. 2008). The integrated approach, by continuously engaging the customers and the stakeholders in the measure identification and implementation, directly addresses the source of this issue.

Results

Figure 4 presents comparison of the average lead times by facility types from actual public utility sponsored RCx projects completed in the Northwestern and the Midwestern parts of the United States. In collecting the data for these plots, the project kick-off meeting was considered the starting date and the verification report date was considered the project end date. Since the integrated RCx approach was formally introduced only recently, a small sample size of completed projects representative of the integrated approach was selected for our paper.

Figure 4. Project Lengths, Traditional Vs. Integrated RCx Approaches



Sample Size (n): Traditional Approach=54, Integrated Approach=7

Deriving from data obtained from projects following the respective models, the costs for the integrated approach were higher than that of the traditional approach by about 10% while the average start-to-finish time (i.e., lead time) for the integrated approach is reduced by nearly 50%. The increased cost for the integrated approach can be attributed largely to a higher level of effort during Planning Phase that included the creation of a prioritized list of measures and the increased coordination efforts between all stakeholders in the integrated Investigation-Implementation Phase.

Conclusion

While the traditional RCx approach continues to provide significant value to the customers, the integrated RCx approach is an important improvement that facilitates an organized flow of processes. The RCx project managers/administrators have observed that the structural change in the integrated approach facilitates an inherently faster yet effective measure implementation, while not sacrificing well-documented energy savings. The integrated approach can work especially well in regions that have a low variance in seasonal outside air conditions. In regions where there are significant seasonal changes in outside air conditions, additional efforts will have to be exercised in coordinating and managing the timely completion of the essential deliverables. The integrated approach can also work well where quick turnaround is a requirement either from the building owner or the funding entity.

With a solid definition of the roles and responsibilities, project goals, and a team of prime movers, the integrated approach can prove to be lean and mean way of achieving a successful RCx project beneficial to all parties.

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