

Retro-Commissioning: Going Beyond the Energy Audit

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Synopsis

In the past several years since the term retro-commissioning has been coined there has been a wide range of services provided under the guise of retro-commissioning. Unfortunately, most of these services are just a glorified energy audit and do not actually use any of the principles or techniques of the commissioning process. In this paper, the process side of retro-commissioning will be detailed, including the development of the project (operational) intent and basis of design (operation), verification of documentation and system operation, training of O&M personnel, and matching the owner's requirements with the system either through improving the system or lowering the expectations.

In addition, the results from projects where the process was followed will be given. Of particular interest are those non-energy items (indoor air quality, comfort, functionality, etc.), that are missed if the process detailed in this paper is not followed.

About the Author(s)

Chad Dorgan is an international leader in the development and adoption of the commissioning process by owners. Dr. Dorgan's primary focus has been on the simplification and clarification of the tools used throughout the commissioning process and the documentation of the benefits to the owner, occupants, design professionals, contractors, and others.

Charles Dorgan was the recipient of the 1st Annual Benner Award for his lifelong dedication to making the commissioning process business as usual. Dr. Dorgan has been continuously involved with the development of ASHRAE's commissioning process guidelines and is the committee's current chair.

Zach Obert has been the commissioning authority on numerous retro-commissioning projects and has specialized in the development of computerized tools to simplify the implementation and completion of the commissioning process tasks. Mr. Obert's efforts has led to a reduction in time, improvement in quality, and increased acceptance of the commissioning process by all commissioning team members.

The Retro-Commissioning Process

On a weekly basis, I will receive a request from a colleague or client to explain what is this “Retro-Commissioning Process” service that consultants are now offering, or I will receive a copy of a “Retro-Commissioning” report to comment on. Based on this experience, the majority of retro-commissioning services that are being offered are repackaged energy audits. This is unfortunate, as for the same effort, the client can achieve so much more value when the actual retro-commissioning process is utilized.

So, what is the retro-commissioning process? At its core, retro-commissioning follows the same steps and activities as the commissioning process, just modified for an existing operating facility and not a new or renovation project. Therefore, the key activities to be accomplished are:

- Document the Project (Operational) Intent
- Document the Basis of Design (Operation)
- Develop Recommendations
- Accomplish training of the operations and maintenance staff
- Develop usable and useful documentation

Operational Intent

The key to the success of a retro-commissioning project is to approach it without preconceived notions of what the owner requires. Unlike an energy audit where the entire focus of the project is to evaluate the systems for energy reduction opportunities, the retro-commissioning process focuses on documenting what the owner’s requirements are, then evaluating how best to meet them. While energy is often one of these requirements, it is not the sole one.

The development of the Operational Intent is best accomplished using a workshop format, as is used in the commissioning process. It is critical that the Operational Intent be properly developed and documented as the remaining work focuses on achieving the criteria and requirements in this document. The steps accomplished in developing the Operational Intent are:

- Develop the Questions
- Organize the Workshop
- Convene the Workshop
- Transform the Results
- Present the Results
- Update the Procedures

Develop the Questions

In order to elicit discussion among the workshop attendees it is important that the questions posed are broad in nature, obtain a variety viewpoints, and do not lead the discussion down a single path.

Since retro-commissioning deals with existing facilities, working with the client contact often provides guidance on which topic areas need addressing. In general, the topics that should always be included are those dealing with the use of the facility, how is comfort defined, and how will the facility be evaluated for on-going success?

The following are questions used in past Operational Intent workshops:

- *What are the functional uses of this facility?* This question is intended to obtain information of what is required to have a functional facility. The broad nature of the question and the varying individual definitions of what a functional use is do not cause problems. Actually, this variance enables us to get the attendees input and perceptions, not our filtered view.
- *What conditions are important to your comfort in an ideal building?* The term “ideal building” is used so that the attendees focus on what they want and not what is causing them problems. This results in much more cohesive and focused criteria.
- *What do you do when you become uncomfortable?* This question provides critical information on how the individual reacts, or can react, when uncomfortable and helps in identifying management system limitations.
- *What criteria should be used to evaluate the success of the facility?* While simple in nature, most people do not think about how they evaluate success, they just do. Asking this question obtains some interesting responses and gets the attendees thinking about the future.

Organize the Workshop

The two key aspects of organizing the workshop are who to invite and how long should it be?

Since this is an existing facility, the people to invite are the major stakeholders essentially anyone who will use the facility or is responsible for its operation. For example, for an office building this would not only include the owner and operations and maintenance staff, but would also include key tenants or organizations within the building, customers, potential tenants, and possibly neighborhood associations. The person identified to represent their group must be knowledgeable of the group’s activities and needs, be able to speak for the group, and to communicate the results of the workshop and the Operational Intent document back to their group.

Due to the limited time most people have available, it is recommended to keep the length of the workshop to a half day for the entire group, and another half day with the operations and maintenance staff to get additional detailed input. Typically, each workshop question takes 30 minutes to complete, ranging from 20 minutes to 45 minutes depending upon the number of attendees, the number of responses, and the discussion.

Convene the Workshop

To obtain the maximum amount of information, the room where the workshop is held should be comfortable, limit the distractions from outside sources (phone calls, urgent questions), and food and drinks provided.

The workshop facilitator (Commissioning Authority) uses the following procedure for each question:

- Commissioning Authority states the question
- Quiet response time – approximately 5 minutes
- Record individual responses on a flip chart with no discussion – approximately 10 minutes
- Discuss the responses – approximately 5 to 10 minutes
- Individual ranking of the top 5 responses – approximately 5 minutes

The Commissioning Authority first states the question, provides simple explanation to get the attendees started, and ensures there is no discussion among the attendees as they write down their responses. This is followed by round robin recording of the individual responses onto a flip chart. It is critical that there is no discussion during this recording so that each individual is comfortable with responding – there are no wrong answers. The limiting of discussion also avoids a single person from dominating the discussion.

After all responses are recorded the Commissioning Authority goes back through each one, obtains clarification, and combines similar responses based on input from the attendees. No responses are eliminated.

The last task is for each attendee to choose and rank their top five responses.

Transform the Results

With the workshop complete, a ranked list of items has been obtained of what is important for this facility to be successful. Each of these criteria now needs to be transformed to be measurable, verifiable, and documentable. This is not an easy task. For example, one of the responses may be that comfort is defined as good temperature control. The Commissioning Authority must work with the workshop attendees to define what “good” means.

Present the Results

Once the Operational Intent is drafted, it is provided to the workshop attendees for review and comment. To provide the information in a format that is understandable by novices and professionals alike, it is recommended that the Operational Intent proceed from general to specific.

Ideally, a handful of criteria can be isolated that are critical to the success of the facility and will be the focus of the project. These criteria should be highlighted and then detailed. A format that works well for the Operational Intent is:

- Introduction – Includes an overview of the facility and the general requirements.
- Key Requirements – contains a listing of the key requirements and criteria that will be the focus of the retro-commissioning process.
- Functional Uses – The functional uses (spaces and operations) of the facility are detailed, including a short description to provide the context in which it was detailed.
- Occupancy Requirements – Includes the number of occupants (users and visitors) and the schedule of occupancy, including all special conditions.
- Performance Criteria – The performance criteria for which the facility will be evaluated. Each performance criterion should be measurable and verifiable.

Update the Procedures

The last step when doing a workshop is to review the procedures used and update them based on lessons learned from the workshop. This step is typical of all quality processes where the procedures are always improved.

Basis of Operation

With the Operational Intent documented, the next step is to document the Basis of Operation. Whereas the Operation Intent is desired operation, the Basis of Operation is how the facility is actually performing and what the limitations (capacity) are with the various systems and assemblies. The Basis of Operation should include the following information:

- List of systems and assemblies
- Make, model, and other identifying characteristics of each system and assembly component
- Record drawings
- Design/operational assumptions and limitations (maximum outdoor conditions, maximum number of people, etc.)
- Actual conditions (flowrates, capacities, pressure drops, temperature variances, control sequences, etc.)

Documenting the Basis of Operation is composed of verifying the facility documentation and verifying the facility operation.

Documentation Verification

The current facility documentation (record drawings, operation and maintenance manuals, complaint logs, work orders, etc.) are collected and verified for accuracy. The accuracy is verified using a sampling technique. This sampling is the only means to quickly and reliably evaluate the validity of a collection of documents. The procedure to be followed is (record drawing example):

- Divide each drawing sheet into a 3 by 5 grid.
- Select starting grid.
- Verify accuracy of every xth grid.

The percent to verify should be at least 5%, and preferably 10-15%. If there are significant accuracy problems, then the recommendation should be made to the client to accomplish a complete verification and update of the record drawings/documentation.

By accomplishing this verification, the reliability of the documentation is established for the facility and for the retro-commissioning recommendations.

Operation Verification

With the documentation verified, the next step is to verify the operation of the systems and assemblies. This entails the development and implementation of functional performance tests to determine the actual operating conditions and performance characteristics.

Develop Recommendations

It is now a simple comparison of the Operational Intent with the Basis of Operation to identify where the systems and assemblies do not achieve the requirements. Included with each recommendation should be the scope, cost, and benefits of the recommendation, along with what the impact is if the change/improvement is not accomplished.

O&M Training

Often, a primary cause of problems in a facility is due to a lack of understanding of system operation by the operation and maintenance personnel. Therefore, as part of the retro-commissioning process, the Commissioning Authority should develop and implement a focused training program. This should include review of the Operational Intent and Basis of Operation, as well as review of troubleshooting procedures, preventative maintenance, and system optimization.

Systems Manual Development

The final task to be accomplished should be the completion of a systems manual. This is unique from an operations and maintenance manual in that it is systems-based and provides information on facility operation that aids the operators in optimizing and maintaining the Operation Intent.

As technology advances, more and more of the systems manuals developed are in electronic format, with web-based being the most prominent.

Case Study 1: Thermal Storage System

Retro-commissioning was accomplished on a thermal storage system at a television studio two years after the system was installed. We were called in due to complaints of inadequate system capacity, high energy use, and the need to add capacity for a new studio currently under construction. The distribution and air handling systems were not modified. The Operational Intent of the facility was:

- Shift entire cooling load of 1,650 ton-hours and a peak load of 180 tons (chillers) to off-peak periods (10 p.m. to 9 a.m.)
- Supply chilled water at 45F, with ability to supply 38F during certain performances

The layout of the chilled water system is shown in Figure 1. As can be seen, since the distribution system was not modified, control valves were not added to several of the chilled water coils.

The system documentation was verified and was found to be accurate. This was followed by the development and completion of a performance test of the storage capacity. The test used ASHRAE Standard 150-2000, Method of Testing the Performance of Cool Storage Systems as the basis for procedures and measurements. The results of the performance test are shown in .

The results of the performance test indicated that the thermal storage system could provide the capacity as designed. Therefore, the first operational intent was achieved. However, under normal operating conditions, the chillers were still operating during the on-peak periods. After further investigation, the key culprit was the missing chilled water control valves. The air handling units that these control valves were associated with had electric reheat in the space. Without control, the supply air temperature was as low as 47F, which the electric reheat then heated to 70F to maintain space comfort.

The specific recommendations for this project were:

- TES differential temperature increase
 - Install VSD on secondary pumps and control valves on air handling units
 - \$20,400/year savings at a cost of \$17,500
- Control system adjustments
 - Adjust set points and control outdoor air
 - \$2,400/year savings with in-house labor
- TES tank piping insulation/repair
 - Insulate branch piping to tank
 - Install larger band clamps on branch piping
 - \$800/year savings at a cost of \$500

- Overall system improvements
 - Modify operating sequence
 - Add discriminator control (minimize reheat)
 - \$10,050/year savings at a cost of \$14,600

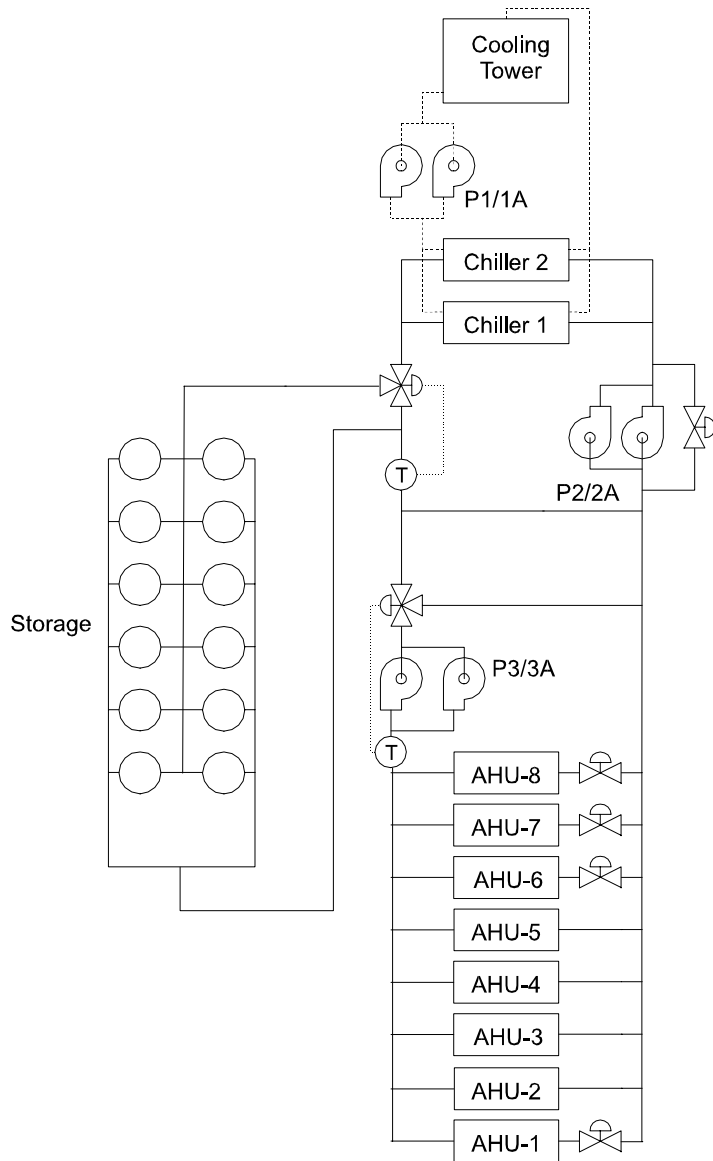


Figure 1: Studio Chilled Water System Schematic

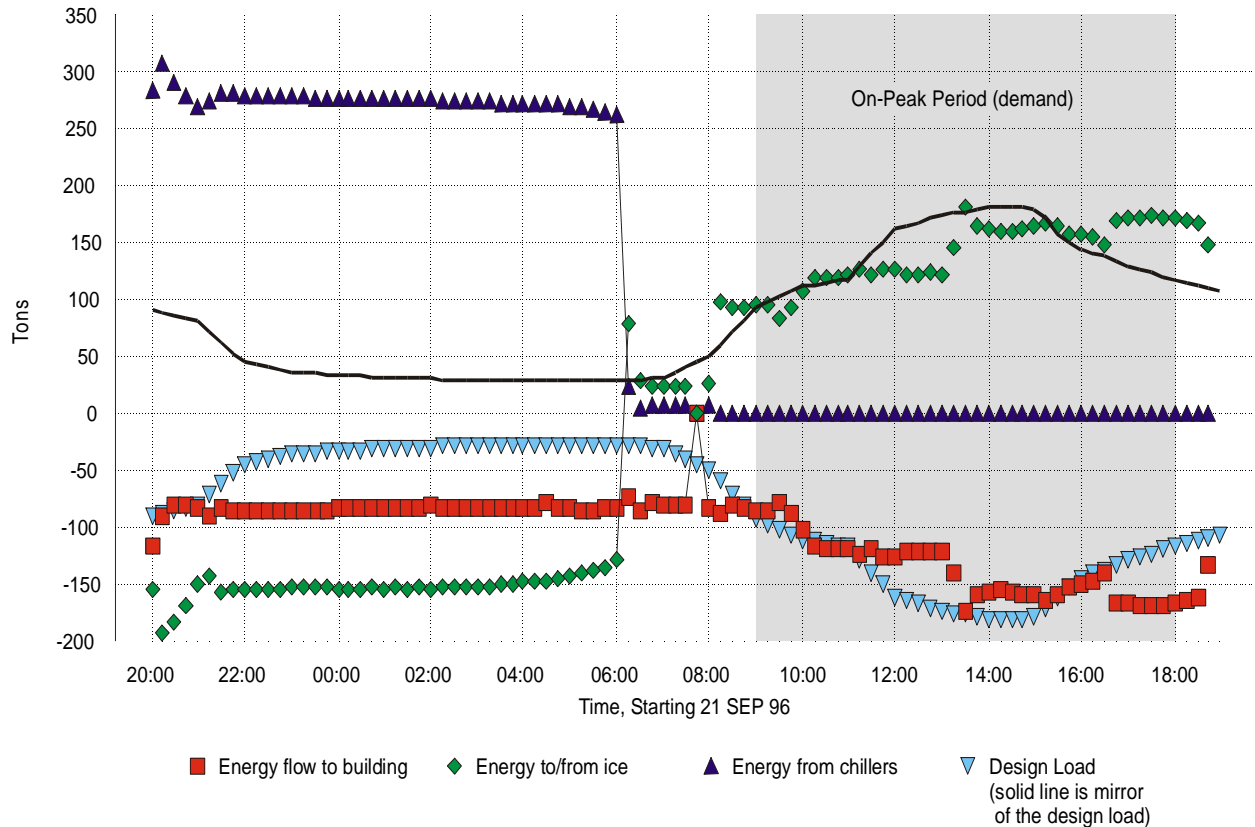


Figure 2: Thermal Storage Performance Test Results

The result of retro-commissioning the thermal storage system for the television studio was improved comfort, reduced energy use, and avoided capital investment (did not need to purchase a new chiller for the new studio). Further, the development of a systems manual that contained clear and concise descriptions of the thermal storage system and its operating strategy, was the first time the operators understood how to operate and maintain the system.

Case Study 2: Medical Office Building

The medical office building was retro-commissioned after two years of occupancy, which was then 60% occupied. With the building being speculatively built, the designers, contractors, and operators had no communication between them as they were all hired at different times. The building was composed of a three-story medical office building (MOB) section and a one-story out patient ambulatory diagnostic and treatment (AD&T) section. The layout of the building is shown in Figure 3.

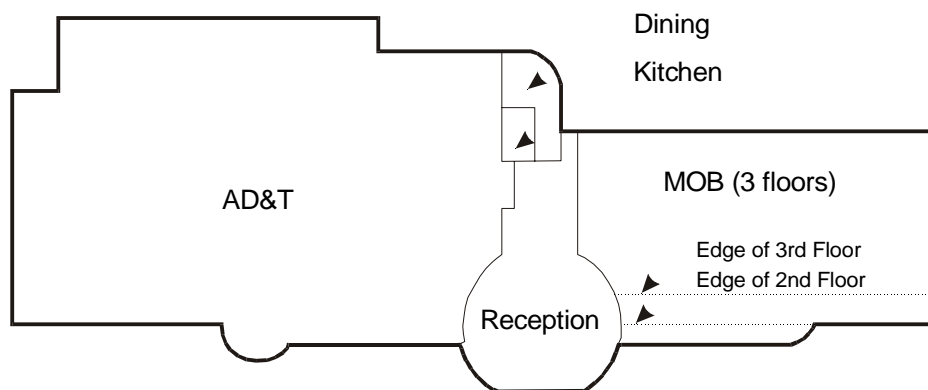


Figure 3: Medical Facility Layout

The Operational Intent for this project was:

- Maintain proper air pressure relationships in clean areas
- Minimize steam energy use
- Optimize tenant fit-out process (offices)
- Maintain a pleasing environment for occupants

As can be seen, three of the four Operational Intents are non-energy related. While the original purpose of the project was to fix the gas energy use problem, once begun, the owner realized that there were other issues that had to be addressed for a functioning facility.

The opportunities identified were:

- Modify steam system to match usage – boiler 20 times oversized (5.7 year payback)
- Modify AHU control to use economizer system (1.4 year payback)
- Install active pressure control on surgery suites for safety and air quality
- Modify lobby airflow pattern to achieve comfort for receptionist
- Implement commissioning procedures on tenant fit-out to avoid future problems
- Install computer interface with existing Trane Tracer system
- Modify hot water freeze protection procedures to reduce energy use
- Implement smoking area policy/system to avoid smoke in the facility

The results of this project were primary occupant comfort and safety issues, not just energy. Therefore, the client received a higher value service that met all of their known and unknown needs.

Conclusions

The retro-commissioning process goes well beyond the traditional energy audit to be a more holistic approach to operating facilities. The process and procedures detailed in this paper are intended to provide guidance on how to adopt the quality tools from the commissioning process

for existing facilities. The practitioner of the retro-commissioning process is encouraged to always look for better ways to achieve the client's Operational Intent and maximize the value to the client.

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