

State of California
Guide to Commissioning Existing Buildings

[Logo(s): CCC/CEC/DGS ???]

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Acknowledgements

The information in this document is drawn from several existing guides to retrocommissioning:

New York State Energy Research and Development Authority (NYSERDA). *Guideline to the Building Commissioning Process for Existing Buildings, or “Retrocommissioning”* (2003), prepared by Portland Energy Conservation, Inc. (PECI).

Federal Energy Management Program, U.S. Department of Energy. *Continuous CommissioningSM Guidebook, Maximizing Building Energy Efficiency and Comfort* (2002), prepared Energy System Laboratories of Texas A&M University and University of Nebraska.

Oregon Department of Energy. *Retrocommissioning Handbook for Facility Managers* (2001), prepared by Oak Ridge National Laboratory and Portland Energy Conservation, Inc. (PECI).

U.S. Department of Energy. *A Practical Guide for Commissioning Existing Buildings* (1999), prepared by Oak Ridge National Laboratory and Portland Energy Conservation, Inc. (PECI).

U.S. Environmental Protection Agency and U.S. Department of Energy. *Operations and Maintenance Assessments: A Best Practice for Energy-Efficient Building Operation* (1999), prepared by Oak Ridge National Laboratory and Portland Energy Conservation, Inc. (PECI).

U.S. Department of Energy, Rebuild America Program. *Building Commissioning: The Key to Quality Assurance* (1998), prepared by Portland Energy Conservation, Inc. (PECI).

Many people contributed their time and expertise to writing and reviewing this guide:

About this Guide

This Guide describes the building commissioning process for existing buildings, commonly referred to as *retrocommissioning*. You can read it cover-to-cover, or skip around to find just the information you need.

In new buildings, commissioning is a quality assurance process that spans the entire design, construction and turnover process, helping ensure that the building's performance meets owner expectations. Retrocommissioning is a systematic process for improving an existing building's performance by identifying and implementing relatively low-cost operational and maintenance improvements. This Guide is written for building owners and managers, but others involved in the retrocommissioning process will also find it useful.

The Guide answers the following questions:

- What is retrocommissioning and why should I use it?
- What are the benefits and costs of retrocommissioning?
- What happens during the retrocommissioning process?
- Who should be a part of the retrocommissioning team?
- How can I ensure that the benefits achieved from retrocommissioning are long-lasting and that operations at my facility are efficient over the long term?
- How do I get started with a retrocommissioning project?

This Guide is not a how-to manual for retrocommissioning. Rather, it provides the necessary foundation for anyone considering a retrocommissioning project.

1. Introduction

This chapter introduces the commissioning process as it applies to existing buildings. It answers the questions:

- What is building commissioning?
- Why is retrocommissioning important?
- What are the goals of the retrocommissioning process?

Online Resources

www.cacx.org

California Commissioning Collaborative
Contains a collection of commissioning and energy efficiency case studies

www.usgbc.org/LEED/EB

U.S. Green Building Council

LEED (Leadership in Energy and Environmental Design)
Green Building Rating System for Existing Buildings (EB)

Publications

What is Building Commissioning?

The term commissioning comes from shipbuilding. A commissioned ship is one deemed ready for service. Before being awarded this title, however, a ship must pass several milestones. Equipment is installed and tested, problems are identified and corrected, and the prospective crew is extensively trained. A commissioned ship is one whose materials, systems and staff have successfully completed a thorough quality assurance process.

Building commissioning takes a similar approach. When a new building is commissioned, it undergoes an intensive quality assurance process that begins during design, construction, and turnover, and continues into and occupancy and operations. Commissioning ensures that the new building operates as the owner intended and that building staff are prepared to operate and maintain its systems and equipment.

What is Retrocommissioning?

When commissioning is applied to existing buildings, it is known as *retrocommissioning*, a process that seeks to improve how building equipment and systems are operating and functioning together. Depending on the age of the building, retrocommissioning can often resolve problems that occurred during design or construction, or address problems that have developed during the building's life. In all, retrocommissioning improves a building's operations and maintenance (O&M) procedures to enhance overall building performance.

What is Recommissioning?

Recommissioning is another type of commissioning that occurs when a building that has already been commissioned undergoes another commissioning process. The decision to recommission may be triggered by a change in building use or ownership, the onset of operational problems, or some other need. Ideally, a plan for recommissioning is established as part of a new building's original commissioning process or an existing building's retrocommissioning process.

Retrocommissioning, and then recommissioning every

Note

For more information on new construction commissioning, consult the full-length State of California Guide to Commissioning, a companion to this publication.

Definition:

Retrocommissioning (RCx)

Retrocommissioning is a systematic method for investigating how and why an existing building's systems are operated and maintained the way they are, and identifying ways to improve overall building performance.

Cross Reference

A more detailed discussion of recommissioning can be found in *Chapter 5: Strategies for Ensuring Persistence of Savings*.

five years, is required of all State of California buildings more than 50,000 square feet in size. Commissioning is also required of all new State buildings, as it is a required part of LEED.

Why is Retrocommissioning Important?

Commercial buildings frequently undergo operational and occupancy changes which challenge the mechanical, electrical and controls systems to continue to perform optimally. In addition, today's complex buildings have highly interactive systems, allowing even small, seemingly insignificant problems to have cascading effects on building operations – leading to energy waste and uncomfortable or unhealthy space conditions.

Retrocommissioning helps to ensure that building equipment and systems are integrated so they perform together effectively and efficiently, and meet the building owner's current operating requirements and expectations.

Unfortunately, most buildings have never gone through any type of commissioning process, and even well-constructed buildings will have performance degradation over time. And no matter how well building operators and service contractors *maintain* equipment, if it *operates* inefficiently or more often than needed, problems occur.

Even if building staff have been able to work out most of the operational “bugs” in the building systems, they are often forced to solve problems under severe time constraints and without the benefit of proper documentation. Having to address such problems too fast and without adequate information can result in “quick and dirty” solutions that can lead to other building problems.

The result of this conflict? Poorly performing buildings, in which:

- System and equipment problems result in higher than necessary utility bills.
- Unexpected or excessive equipment repairs and replacement costs eat up money and staff time.

- Poor indoor environmental quality causes employee absenteeism, tenant complaints and turnover, and, in the most severe cases, leads to lawsuits and expensive retrofits.

Retrocommissioning – when appropriately applied – goes beyond quick-fix solutions to systematically improve building systems so that they operate efficiently, effectively, and reliably, and ensure the improvements persist over time. Additionally, retrocommissioning:

- Supplies the owner and building operators with documentation, including what was done and why, as well as any new O&M strategies.
- Includes building staff throughout the process, providing valuable on-the-job training for operators.
- Identifies potential indoor environmental quality issues and eliminates occupant complaints.

Why Preventive Maintenance Isn't Enough

Preventive maintenance tends to focus on component-by-component care, rather than taking the holistic view that *operation* is of equal importance to *maintenance*. Preventive maintenance measures, such as cleaning coils, changing filters, tightening belts, and calibrating strategic sensors, are essential to the ongoing operations of a facility, but performing these tasks alone is not enough.

Good O&M practices also entail observing and monitoring building systems to determine how and when they operating. However, in a typical building, staff are often taxed with nuisance problems and trouble calls and too strained to proactively pursue operational tasks. And, even if building staff are performing some monitoring and data collection, it is rarely in their skill set or job description to systematically analyze the information for deficiencies that are beyond the obvious.

Retrocommissioning goes beyond the day-to-day upkeep of your building and provides a thorough assessment of the operation of mechanical equipment, lighting, and related controls, and is intended to improve how equipment operates as a system.

Cross Reference

A more detailed discussion of enhancing preventive maintenance can be found in *Chapter 5: Strategies for Ensuring Persistence of Savings*.

Note

Periodically monitoring critical pieces of equipment to ensure proper operation should be as important as periodically performing maintenance tasks, such as cleaning coils, lubricating motors, or changing filters. Yet typically, little training is devoted to understanding building operation and system interactivity, and there is insufficient time left after “fighting fires” to accomplish this kind of monitoring.

Note: Common Retro-commissioning Findings

Retrocommissioning involves a systematic, in-depth investigation of building operations, finding deficiencies that may not be immediately obvious or visible. Some examples include:

- Variable speed drives are no longer modulating appropriately
- Controls are circumvented or set up improperly
- Equipment is running more than necessary or running inefficiently because of improper sequences of operation
- Controls were never tuned or need to be retuned to provide appropriate response time or to avoid hunting

Goals of the Retrocommissioning Process

All forms of building commissioning essentially share the same goal: to ensure that a building meets the unique needs of its owner and occupants, operates as efficiently as possible, and provides a safe, comfortable work environment.

Retrocommissioning is a team effort and, depending on the scope of the project, many individuals may be brought in to participate. Every project needs a designated leader to facilitate the process and ensure that the owner's expectations are met at each stage of the project. Depending on the complexity of the building systems and the expertise and availability of the in-house building staff, a building owner may choose a third-party commissioning consultant to lead the project from start to finish. However, some building owners and managers have successfully managed their own commissioning projects, utilizing in-house staff and bringing in a commissioning expert for certain tasks.

Retrocommissioning has several goals, including:

Ensure that the building is performing efficiently and as expected. As part of the retrocommissioning process, the commissioning team reviews the current O&M documents and practices, analyzes energy use, and observes and tests building equipment and systems.

Recommend and implement measures that improve equipment performance. The commissioning provider documents any deficiencies detected in the operation of the facility's mechanical equipment, lighting, and related controls, and determines opportunities for corrective action. Some of these opportunities will be pursued during the retrocommissioning process, while others will be deferred.

Verify that the building owner and staff receive adequate documentation and assistance to implement improvements, as well as training on monitoring and maintaining improvements. Key deliverables from the process, such as the *Master List of Findings* and *Final*

Cross Reference

A more detailed discussion of the retrocommissioning team, typical roles in the project, and project management arrangements can be found in *Chapter 4: The Retrocommissioning Team*.

Report, become new documents for the building record and important references for implementing, operating and maintaining the measures. Ideally, training for building staff is ongoing throughout the retro-commissioning process and the commissioning provider ensures that the operators understand the O&M requirements needed to keep the improvements working.

Provide documentation and tools to enhance O&M practices. Tremendous value can be added to a retrocommissioning project by taking the opportunity to update and enhance the building documentation and develop new tracking systems for monitoring whole-building and equipment performance.

A well-planned, thorough retrocommissioning process that strives to meet each of these goals can result in far-reaching benefits for the building owner, staff and occupants. As every building's operating conditions and challenges are unique, so is the retrocommissioning process that is applied to it. The remainder of this Guide provides building owners and managers with information they need to obtain the most value out of retrocommissioning their buildings.

Commissioning and LEED

What is LEED™?

LEED stands for Leadership in Energy and Environmental Design, a green building rating system developed by the U.S. Green Building Council (USGBC).

LEED helps owners, architects, engineers and contractors evaluate a facility's "environmental performance from a whole building perspective over a building's life cycle" and provides "a definitive standard for what constitutes a 'green building.'"

LEED for Existing Buildings (LEED-EB) is applicable to building operations, processes, system upgrades, and minor space changes, and can be used by buildings new to LEED certification, or as a recertification vehicle for buildings that have previously achieved a LEED rating. As with other LEED systems, existing buildings achieve one of four ratings: Certified; Silver; Gold; and Platinum.

What is the LEED-EB rating system?

The LEED-EB guidelines specify performance standards for building operations and upgrades of existing buildings in each of six categories:

- Sustainable sites
- Water efficiency
- Energy and atmosphere
- Materials and resources
- Indoor environmental quality
- Innovation and design process

In order to be LEED certified, a project must meet all the "prerequisite" requirements in each category. Projects then earn "points" by selecting more advanced criteria from various categories. The more points a project earns, the higher its LEED rating. This point system allows projects a great deal of flexibility in producing a LEED certified building. Upon completion, a certification package is created that documents the measures that were implemented, and the USGBC evaluates the submission and grants a LEED rating along with a plaque and recognition on the USGBC Web site.

What are the LEED-EB commissioning requirements?

All buildings seeking LEED-EB certification must provide documentation that a commissioning process that meets the LEED rating system guidelines has been completed at the facility, or provide a 5-year plan for completing the process. The LEED-EB guidelines also contain several related credits that may be incorporated to earn an "additional point," such as credits for monitoring energy performance and reducing overall energy use, and supporting operations and maintenance plans and providing staff education.

Projects undertaking LEED certification should consult the most recent version of the LEED Green Building Rating System for detailed information. More information about the LEED rating system can be found on the U.S. Green Building Council's Web site at www.usgbc.org.

2. Benefits and Costs of Commissioning Existing Buildings

The benefits of undertaking retrocommissioning are numerous. They include both energy savings and other, significant non-energy benefits. This chapter discusses what a building owner or manager should expect in benefits as well as costs, and shares some strategies for reducing costs of retrocommissioning.

This chapter answers the questions:

- How does retrocommissioning reduce a building's energy use?
- What cost savings can an owner expect?
- What are the other benefits of retrocommissioning?
- How much does retrocommissioning cost?

Online Resources

Publications

“The Cost effectiveness of Commercial-Buildings Commissioning” (2004). Evan Mills, Lawrence Berkeley National Laboratory

Energy Savings

More and more building owners and managers want to reduce energy use in their facilities. Retrocommissioning provides a comprehensive analysis of a building's performance, giving owners and their building staff the knowledge they need to take action.

A robust retrocommissioning process results not only in an analysis, but in specific recommendations about how to reduce the building's energy use and detailed guidance on how to implement the most cost-effective improvements. Depending on the project scope, these improvements can range from simple, low-cost fixes to complicated, highly integrated operational measures that are coupled with equipment retrofits. When a building operates as efficiently as possible while meeting the owner's operating requirements, retrocommissioning has been successful.

Retrocommissioning is different from routine maintenance in that it adds a focus on operational performance, while maintenance practices tend to be centered on reliability and capacity. The commissioning team employs several strategies to improve a building's performance and reduce energy use. Early in the project, they perform a utility bill analysis to better understand how the building is consuming energy. In the investigation phase, they look for common operating issues, like coincident heating and cooling, which lead to energy waste. Throughout the project, the team takes a holistic view of the building operations and looks for ways to improve *how equipment functions together as a system*.

Energy savings from retrocommissioning can be significant. Whole-building energy use is often reduced by 8% to 15%, leading to cost savings in the thousands of dollars.

Energy and its related cost savings used to be the most commonly mentioned benefit of retrocommissioning.

Note

Building commissioning is an effective way to meet energy efficiency goals. In California, state-owned buildings are required to reduce their energy consumption by at least 20% by 2015.

State of California Green Building Action Plan, March 2005. Detailed Direction that accompanies Governor's Executive Order S-20-04. Section 1.1.2.1.

Quote:

From building owners/managers offering examples of how Cx saves energy.

Note: Cost Savings from Retrocommissioning

Retrocommissioning can produce significant cost savings in existing buildings. Cost savings are usually presented as a range, since actual savings vary depending on the building type, its location, and the scope of the retrocommissioning process. A comprehensive study found the following cost savings ranges:

	(\$/sqft)
Energy savings	\$0.11 → \$0.26
Other cost savings	\$0.11 → \$0.18

(Annex Report, 2005 – not yet citable)

Example: Cost Savings from a Retrocommissioning Project

While energy savings are significant, many owners and occupants find that retrocommissioning's other benefits are equally important.

Non-Energy Benefits

Retrocommissioning's other benefits are far-reaching. They include not only cost savings, but improvements to almost every aspect of operations and maintenance.

Everyone benefits from retrocommissioning. Owners see reduced costs and improved net operating income. Building managers notice fewer occupant complaints and increased ability to manage systems. Building staff receive training and improved documentation.

The other, non-energy benefits of retrocommissioning are usually not expressed in monetary terms, yet the problems they solve often lead building owners and managers to undertake a retrocommissioning process.

Assist Owners and Managers with Long-term Planning

Complete and accurate building documentation helps building owners and managers plan for the future. Up-to-date O&M manuals, sequences of operation, and system diagrams are essential to maintaining and troubleshooting equipment. A *Preventive Maintenance Plan* and a *Recommissioning Plan* describe in detail the human and financial resources that will be necessary to maintain the building several years down the road.

If an owner makes documentation a priority, the commissioning provider can produce this information as a part of the retrocommissioning process. However, it will be important for the owner to specify the deliverables he or she expects at the outset, and be sure they are written into the commissioning provider's scope of work.

Improve System Operation: Beyond Preventive Maintenance

Good preventive maintenance practices are important, but sometimes they are not enough. Where preventive maintenance focuses on individual equipment and components, retrocommissioning takes a holistic view of system operation. The retrocommissioning process goes beyond day-to-day upkeep to provide a thorough assessment of the operation of mechanical equipment,

Note: Non-energy Benefits of Retrocommissioning

- Assists building owners and managers in long-term resource planning and major maintenance budgeting by providing complete and accurate building documentation
- Improves system operation by solving operating, control and maintenance problem
- Improves equipment performance, reduces maintenance costs, reduces premature equipment failure and extends equipment life
- Ensures a healthy, comfortable, productive environment for occupants
- Provides staff training, increasing staff effectiveness and efficiency
- Reduces risk and increases asset value

lighting, and related controls, and is intended to improve how equipment operates as a system.

Retrocommissioning performed by an experienced provider can identify and solve problem that building staff lack the knowledge or time to attend to.

Improve Equipment Performance

Retrocommissioning goes beyond routine maintenance to identify and help solve operational problems that could impair equipment function or even cause premature failure.

During retrocommissioning, the provider assesses whether each piece of equipment is performing optimally. When it is not, the provider investigates the cause of the problem and recommends a solution. For example, if the commissioning provider finds multiple chillers operating unnecessarily at low loads, the provider will collect and analyze chilled water system data and recommend a new sequence of operation that ensure chillers cycle on only when needed.

Early detection and resolution of problems improves equipment performance. The result? Equipment that lasts longer, works more reliably, needs fewer repairs, and uses less energy. Equipment that operates properly also demands less “crisis maintenance” from onsite staff and outside contractors, allowing staff to concentrate on their primary duties.

Ensure a Healthy, Comfortable, and Productive Indoor Environment

The quality of a building’s indoor environment affects the health, comfort and productivity of its occupants. Poor indoor air quality can have many causes:

- Moisture and mold in the building envelope
- Inadequate outside air
- Poor diffuser layout
- Inappropriate control of ventilation air

The consequences of poor indoor air quality range from mildly inconvenient to very serious. Temperature and

Note: The IAQ Problem

Indoor air quality (IAQ) is a big problem in U.S. commercial buildings, some 20-30% of which suffer from indoor quality problems.

Poor IAQ is especially troubling in schools, where students spend close to 13,000 hours between kindergarten and 12th grade. The U.S. Environmental Protection Agency reports that half of U.S. schools – where more than 55 million students, teachers and school staff spend the majority of their time – have indoor air quality problems.

Conditions of America’s Schools, February 1995. U.S. General Accounting Office, Health, Education, and Human Services Division, Document#: GAO/HEHS-95-61, Report#: B-259307.

lighting can both cause an uncomfortable work environment, one which hinders learning and lowers an organization's efficiency and productivity. In more severe cases, poor air quality causes headaches, fatigue or severe allergic reactions.

Another common cause of poor air quality is moisture and mold in the building envelope. Retrocommissioning can help prevent this problem because it ensures that adequate fresh air is provided where and when it is needed, and that building staff have sufficient training and documentation to effectively manage the indoor environment.

Incorrect building pressurization can also lead to poor indoor air quality and uncomfortable conditions. This is especially important in facilities with labs, morgues, or any areas where pressurization is used to keep smells or toxins from migrating between spaces. Retro-commissioning ensures that pressure differentials between spaces are correct.

Increasing O&M Staff Capabilities and Expertise

An essential aspect of the retrocommissioning process is providing improved training to building staff. When staff members increase their understanding of building equipment and troubleshooting skills, they are better able to operate and maintain equipment and respond to occupant requests without circumventing energy saving strategies.

Involving staff early gives them the best opportunity to take advantage of training opportunities that occur throughout the retrocommissioning process. Training may include onsite walk-throughs with the commissioning provider and classroom-style presentations.

Increase Asset Value

Together, the benefits from retrocommissioning translate into increased profitability for building owners by way of reduced operating expenses, increased net operating income, and quicker returns on investment. Owners also benefit from higher appraised building values, as equipment that has been well-maintained and operates efficiently increases the asset value of the property.

Note: The Cost of Discomfort

Comfort problems affect every building owner – both those who occupy their facilities and those who lease them out.

Reduced productivity

An uncomfortable building makes everyone less productive. Occupants spend more time complaining and often take more sick days. Building staff spend more time responding to comfort complaints and have less time to attend to their regular maintenance tasks.

Lost tenants

A chronically unhealthy building can cause owners to lose tenants and money. When tenants leave, costs pile up: rent loss due to vacancy, leasing commissions, and new tenant improvements. In addition, word of uncomfortable building conditions is likely to spread among business peers, increasing vacancy periods.

Increased liability

Retrocommissioning Costs

The cost of retrocommissioning is different for each project, and depends on the project's size, complexity, and the scope of the process.

Retrocommissioning costs are usually estimated on a per-square-foot basis, and can vary widely. The retrocommissioning provider's fee is the most obvious cost, but sometimes the cost to other team members who participate in the process, and the cost of correcting problems identified by retrocommissioning are also included.

Retrocommissioning costs are often offset partially, or even entirely, by the resulting energy savings. In fact, payback times are often under one year, and may be as little as a few months. When the dollar value of retrocommissioning's non-energy benefits are taken into account, the cost of retrocommissioning can be offset by more than 30%.

Note: What influences cost of a retrocommissioning project?

Cost tends to be influenced by several factors:

- The number and complexity of buildings, systems and equipment involved.
- The number and type of objectives.
- The availability and completeness of building documentation.
- The availability and expertise of O&M staff.

Note: Retrocommissioning Costs

Actual retrocommissioning costs, as reported in a study of 106 retrocommissioning projects

<u>Description</u>	<u>Median</u>
<u>Retrocommissioning cost</u>	<u>\$0.27/ft²</u>
<u>Retrocommissioning cost – including non-energy benefits (NEBs).</u>	<u>\$.17/ft²</u>
<u>Payback times (standardized US energy prices)</u>	<u>0.7 years</u>
<u>Deficiencies per building</u>	<u>11</u>
<u>Deficiencies per 100,000 ft²</u>	<u>6</u>

Evan Mills, "The Cost effectiveness of Commercial-Buildings Commissioning," Lawrence Berkeley National Laboratory, 2004.

Effectively Utilizing In-house Staff to Reduce Costs of Retrocommissioning

In buildings with experienced, motivated and available facility staff, there are opportunities to utilize these individuals in the retrocommissioning process to help reduce costs. And when facility staff is actively involved – and essentially acts as a partner to the commissioning provider – the benefits can be numerous. The owner saves money. The commissioning provider saves time. And the building staff gains valuable training and insight into the operation of the building.

There are many tasks that skilled staff can undertake to help streamline the process and increase the effectiveness of the commissioning provider's time. These tasks include:

- Gather building documentation.
- Perform appropriate preventive maintenance tasks prior to starting the RCx investigation.
- Install and remove short-term diagnostic monitoring equipment, or assist in performing diagnostic monitoring and functional tests.
- Perform simple repairs and improvements.
- Track measures after implementation.

Each of these tasks is discussed below.

Gather building documentation

Building staff can compile an up-to-date building documentation package prior to the retrocommissioning process. If this is not done ahead of time, the commissioning provider will need to gather this information, which can be an expensive undertaking. The documentation packet should be available on-site and include as much of the following information as possible:

- Drawings relevant to the systems targeted for retrocommissioning (preferably “As-Built” drawings, if accurate)
- O&M manuals
- Testing, adjusting and balancing (TAB) reports
- Original design documentation (if available)

Cross References

Chapter 4: The Commissioning Team discusses the role of building owners, managers and staff in the retrocommissioning process, and what owners should consider in determining the appropriate role for their staff, based on capacity and qualifications.

Chapter 5: Strategies for Ensuring Persistence of Savings discusses how the facility staff can play a key role in ensuring that the savings from the retro-commissioning measures are long-lasting.

- An equipment list with nameplate information, dates of installation, and submittals including pump curves and fan curves
- List of outside service contractors regularly used
- Current maintenance logs or schedules
- Copies of current service contracts
- Control system documentation, such as sequences of operation, special control strategies, control diagrams, points list, control program or code, etc.
- Energy-efficient operating strategies
- Energy bill (electric, gas, steam, chilled water, etc.) or energy accounting information for at least the last 24 months along with a rate schedule, unit price, or supply contract information for each energy type
- Water and sewer usage and billings

Perform Appropriate Preventive Maintenance Tasks

Special care should be taken to make sure that in-house staff or an outside maintenance service contractor completes scheduled preventive maintenance work before retrocommissioning begins. For example, if retrocommissioning occurs during the cooling season, the annual maintenance tasks for the cooling plant and systems should be completed before commencing with the project. It is not cost-effective to hold up the retrocommissioning process because of dirty filters, loose belts, broken dampers, or loose electrical connections. These are typical preventive maintenance tasks that do not require a commissioning provider's expertise.

Assist with Diagnostic Trending and Testing

It is often appropriate and cost-effective to have the most motivated and interested building staff members assist with the short-term diagnostic monitoring, trend logging, and functional testing that occurs during the investigation phase of the project. This helps reduce project costs and provides the building staff with a learning experience that they can reapply later. If building staff are trained to initiate trend logs using the building's EMCS, a commissioning provider can reduce time spent on the task and the owner will not need to hire a controls contractor

to do the trending.

Building staff may also assist with the installation and removal of portable data loggers used for short-term diagnostics and assist with carrying out functional test plans. This also reduces costs and gives the building staff exposure to different approaches to troubleshooting problems and investigating and verifying equipment performance.

Perform Simple Repairs and Improvements

Depending on the skill level of the building staff, they can perform a number of repairs and improvements. Using in-house staff to perform these tasks greatly reduces costs, as it precludes the need to hire outside contractors. The success of this cost-reducing strategy hinges on in-house staff training, knowledge, and willingness to carry out the work. Existing workloads of O&M staff should be analyzed to determine how schedules and workloads will be shifted to accommodate any additional work brought on by retrocommissioning.

Track Measures after Implementation

Immediately after the retrocommissioning measures are implemented, maximum savings can be realized and the treated systems are operating at their peak performance. Over time, however, the efficiency of the systems may decline unless explicit strategies are put into place to maintain and monitor the improvements. Building staff can play a key role in tracking the measures after they are implemented to ensure that they continue to work properly. This will avoid having to bring the commissioning consultant or a contractor back to verify that the savings are persisting.

3. The Retrocommissioning Process

A well-planned and executed retrocommissioning project typically occurs in four distinct phases: Planning, Investigation, Implementation, and Hand-off. This chapter describes activities for each phase of the process.

There is no one-size-fits-all approach to retrocommissioning since every building is unique. A few factors that affect how a retrocommissioning project may be executed include: the condition of the facility, scope of the project, budget, and availability of in-house resources and expertise.

In most cases, the project is led by a third-party commissioning provider with varying degrees of involvement by the building owner and staff. However, some building owners and managers have successfully managed their own commissioning projects, bringing in a commissioning expert for certain tasks. The process laid out in this chapter assumes a third-party commissioning provider is leading the process and performing most of the essential tasks. *Chapter 4: The Retrocommissioning Team* provides more discussion on the various approaches for managing the retrocommissioning process and utilizing in-house staff with advanced skills or previous experience with commissioning.

Online Resources

www.cacx.org

California Commissioning Collaborative

Contains retrocommissioning sample documents, including an existing building commissioning plan, findings log, final report, systems manual, sequence of operations, and request for proposal.

Publications

Planning

Initial planning activities are critical to the success of any retrocommissioning project as they set the objectives and lay the foundation for the project team to move forward.

To plan for a retrocommissioning project, the building owner or owner's representative must determine if their building is a good candidate for retro-commissioning and develop internal goals and support for the project. A commissioning provider or consultant can be hired to assist with this, or be selected after the project is defined internally. With input from the owner, the provider develops the retrocommissioning plan and holds a kick-off meeting with the staff assigned to the project.

The following discusses the major planning phase activities.

Select Your Project

While most buildings can benefit in some way from retrocommissioning, some buildings are better candidates than others. Owners often want to retrocommission their worst performing buildings, but these facilities are not necessarily cost-effective candidates.

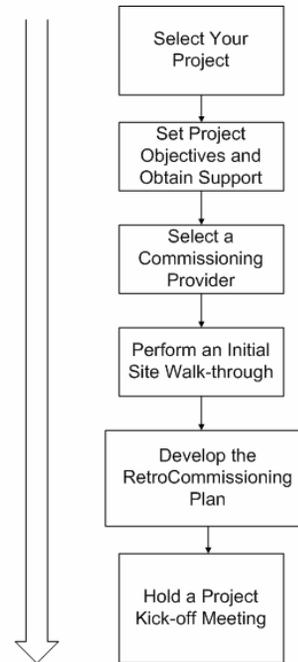
So, what makes a good candidate for retro-commissioning? A few of the top indicators include:

- Unjustified high energy use, or unexplained increases in energy consumption.
- Persistent failure of building equipment or systems.
- Excessive occupant complaints about temperature, air flow, and comfort.

There are several other indicators that may predict the project's chance of success and increase its cost-effectiveness. The characteristics to consider include:

- *Age:* Newer buildings that were never commissioned often provide the most energy savings and non-energy benefits for the least cost.

Planning Phase Retrocommissioning Process



Planning Phase Deliverables

- Retrocommissioning Plan

Note: Choosing from a Portfolio of Buildings

Many buildings are owned or managed by government agencies, investment trusts or property management firms, all of which have diverse building portfolios. These organizations are prime candidates to undertake retro-commissioning because their broad holdings allow them to develop an organization-wide plan for retro-commissioning and then strategically screen and select projects. In these cases, an owner may choose to implement a scoping study of all their facilities, to support development of a multi-year plan.

Equipment age can also have a significant impact on the project, and retrocommissioning *prior to* substantial equipment replacement or retrofit is not always cost-effective for a building owner.

- *Size:* Buildings, large or small, with complex mechanical systems and controls tend to be good candidates for a retrocommissioning process.
- *Building controls:* Buildings with computerized energy management control systems (EMCS) are better candidates than buildings that are fully pneumatic. Pneumatic controls easily drift and therefore need constant attention and calibration for benefits to last. Also, because of its trending capabilities, the EMCS can be used as a diagnostic tool during the retrocommissioning process to capture data.
- *In-house staff:* Retrocommissioning performed on buildings with experienced, knowledgeable, interested, and available building staff is more likely to be cost-effective and have lasting results.
- *Building documentation.* Unless updating the building documentation is a primary objective of the retrocommissioning project, owners should choose buildings with available and up-to-date documents to increase overall cost-effectiveness.

Set Project Objectives and Obtain Support

Once a building is selected for retrocommissioning, the building owner or manager should define the project objectives. The primary objective of the project – such as to obtain cost savings by reducing energy use or to solve an indoor air quality problem – will affect the overall vision, direction and scope. Having the objectives well-articulated at the onset helps to guide the project and keep the team on track through completion of the process.

In order to complete a successful retrocommissioning project, the building owner or manager must secure upper management commitment and support from building staff. Retrocommissioning projects almost always engage building managers and O&M staff, and the most cost-effective and beneficial projects involve close cooperation with at least one operator with

Cross Reference

If significant equipment or controls upgrades or replacements are needed, the owner should consider combining retrocommissioning of the existing equipment and the new installations. *Integrating Commissioning with Building Retrofits*, page 37-38, provides an overview of this process.

Cross Reference

How do you know how your building's energy use compares to buildings of a similar size and type? *Chapter 5: Strategies for Ensuring Persistence of Savings* discusses various publicly-available benchmarking tools.

When is retrocommissioning not appropriate?

- Most of the equipment and systems are outdated or at the end of their life
- Major system design problems exist
- Catastrophic failures of major equipment have occurred

Example: Set of Objectives for a Retrocommissioning Project

- Obtain and verify cost-effective energy savings. Verification will require limited performance monitoring of selected building systems.
- Identify and recommend improvements to operational strategies, focusing on those measures that sustain optimal energy performance and reduce operating costs.
- Identify HVAC-related health and safety issues.

expertise in the building control system, HVAC equipment, and lighting systems.

No less important is acquiring occupant cooperation and support, and allocating adequate time and funds to the project.

Select a Commissioning Provider

The owner can bring a commissioning provider on board at the onset of the project, or after they have selected the building, defined the objectives and garnered internal support for the project. Overall, the commissioning provider leads the process, works closely with the building staff, and ensures that the owner's expectations are being met at each stage of the project.

The commissioning provider has many responsibilities and must be skilled in fostering communication and promoting a positive, team-based approach to problem solving. A well-qualified commissioning provider also has a depth of troubleshooting experience, and the diagnostic monitoring, testing and analysis expertise needed to uncover potential problems and select the most cost-effective solutions.

Perform an Initial Site Walk-Through

To start the project, the commissioning provider should do a walk-through of the facility and get acquainted with building staff assigned to the project. This allows the commissioning provider to gain familiarity with the building and its main energy-consuming systems and equipment and identify areas of opportunity for further investigation.

The provider can gain a lot of understanding about a building just by observing the overall condition of the equipment, the equipment in action, and the positions of valves and dampers. The commissioning provider should interview the building operators about operating conditions, current preventive maintenance actions, and any known performance problems. A few hours with a knowledgeable building operator can uncover numerous areas of energy waste, as they best know the day-to-day operations and the building's weak spots.

Note: Project Champion

The most successful retro-commissioning projects have an internal "champion" to help push the project, convince others of its value, and advocate for the necessary time and money to complete the process. The champion is the person with the most enthusiasm about the project, and is not necessarily the highest ranking person.

Cross Reference

Chapter 4: The Retrocommissioning Team provides guidance on qualifying and selecting a commissioning provider that best meets the project's needs.

Note

Depending on the scope and complexity of the project, as well as the capacity and ability of in-house staff, the owner may wish to select a third-party commissioning consultant to be the lead commissioning provider. An alternative is to select a building or facility manager to manage the project, and bring in a commissioning expert to assist with certain tasks. Different approaches for managing and leading the project are discussed in *Chapter 4: The Retrocommissioning Team*.

Note: Common Indicators of Retrocommissioning Opportunity:

- Presence of systems that simultaneously heat and cool, such as constant and variable air volume reheat
- Presence of economizers
- Pumps with throttled discharges
- Equipment or lighting that is on when it may not need to be

The provider should also obtain utility data from the previous 12 to 24 months as well as review preventative maintenance records and current service contracts. This information will allow the provider to conduct a utility bill analysis and further understand the current O&M practices at the facility.

Develop the Retrocommissioning Plan

After gaining a clear understanding of the project goals and current operating conditions at the facility, the commissioning provider develops the *Retrocommissioning Plan*.

The *Retrocommissioning Plan* is developed with input from the building owner or assigned staff and reiterates the scope of the retrocommissioning project. This deliverable ultimately serves as a guideline for team members to follow. It provides an outline of the processes and procedures that will be undertaken, a schedule of activities, roles and responsibilities of team members, and forms and templates that will be used to document the retrocommissioning activities.

The plan should be viewed as a flexible document that is revisited at certain milestones in the project.

Hold a Project Kick-off Meeting

The project kick-off meeting brings the project team together to review the *Retrocommissioning Plan*. The commissioning provider organizes and leads the meeting. Participants may include the owner or owner's representative, building operators and O&M staff, and any contractors or other professionals that may be important to the process, such as controls contractors, maintenance service contractors, or consulting engineers that are familiar with the building and the owner's operating requirements. At this meeting the owner and provider identify each team member's responsibilities and communicate the owner's expectations for the project.

- Improper building pressurization (either negative or positive); i.e., doors that stand open or are difficult to get open
- Equipment or piping that is hot or cold when it shouldn't be; unusual flow noises at valves or mechanical noises
- Short cycling of equipment
- Variable frequency drives appear to operating at or close to 100% when they may not need to be

Definition: Retrocommissioning Plan

A document that defines the project's objectives, scope, schedule, documentation requirements, and the roles and responsibilities of team members. The plan should include:

- General building information and contact information
- Goals and scope of the project
- Brief building and system descriptions, including a list of systems that will be investigated
- List of team members, their roles, responsibilities, and expected deliverables
- Description of the communication, reporting, and management protocols
- Schedule (for primary tasks)
- Documentation request
- Investigation scope and methods
- Implementation phase requirements
- Project hand-off activities

Retrocommissioning Plan templates and samples are available on the CCC website: www.cacx.org.

Cross Reference

In *Chapter 4: The Retrocommissioning Team*, the responsibilities of the commissioning provider and other retrocommissioning team members are discussed.

Investigation

During investigation, the commissioning provider conducts a methodical analysis of the building operations through observation, review of building documents and O&M practices, and trending and testing of building systems. The results of this analysis are summarized for the owner in a *Master List of Findings*.

The following discusses the major investigation phase activities.

Review Facility Documentation

Thorough building documentation review allows the commissioning provider to better understand the building's major energy uses and integration issues. Ideally, a building operator assigned to the project will be available to help gather the appropriate building documentation and answer questions for the provider.

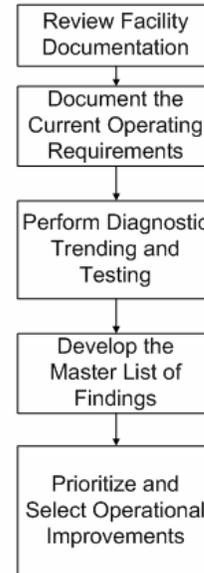
To the extent possible, the commissioning provider should obtain and review the following documents:

- Original owner's project requirements, including design narrative and basis of design (if available).
- Equipment lists, with nameplate information.
- Drawings for the building's main energy consuming systems and equipment, including: controls, HVAC, terminal equipment, ducting and piping, and electrical.
- Control system documentation, including sequences of operation, point lists, and control diagrams.
- Operation and maintenance manuals.
- Test, adjust and balance (TAB) reports.

Document the Current Operating Requirements

An important objective of a retrocommissioning project is to ensure that the facility's operating requirements are being met, so one of the early

Investigation Phase Retrocommissioning Process



Investigation Phase Deliverables

- Diagnostic Trending and Testing Plans
- Master List of Findings
- Summary Report (optional)
- List of improvements selected for immediate implementation

Note

Having building documentation available and up-to-date will help to increase the cost-effectiveness of the retrocommissioning process, as it spares extra hours the provider would otherwise have to expend searching for information or creating new documentation.

retrocommissioning tasks is to define these requirements. These requirements include any requirements or limitations for temperature, humidity and air filtration. If the owner's operating requirements are not a part of the building record, the commissioning provider should document this information for all areas of the facility that have different uses.

Also, as the commissioning provider proceeds, it is important to be aware of the owner's operating requirements, so as to be sensitive to building schedules, functions, and processes during the diagnostic activities of the investigation.

The owner's operating requirements are also important to consider as they may affect the feasibility of some retrocommissioning measures. For example, scheduling of equipment or lighting may not be a possible energy-saving measure in an area of the facility that has extended or unusual operating hours.

Perform Diagnostic Trending and Testing

By now, the commissioning provider has completed a significant amount of information-gathering and assessment by way of one or more facility site visits, interviews with the building staff, and careful review of facility documentation. Based on what has been gathered, the commissioning provider likely has a good sense of the primary areas of opportunity for retrocommissioning at the facility.

To identify, confirm, or characterize improvement opportunities, or to detect the root causes of operational deficiencies, the commissioning provider needs more complete and exact data on when and how the systems are operating. To do this, the commissioning provider develops appropriate diagnostic trending and test plans.

Trending allows the commissioning provider to observe performance of the systems under various modes and operating conditions over time. Time-series data are collected and analyzed, allowing sampling and storing of various parameters at intervals ranging from one minute to one day. Some of the variables

Definition: Owner's Operating Requirements

A written document that details the facility's operating requirements including operating hours, process and equipment status during off-times, and requirements and limitations for temperature, humidity or air filtration.

Definition: Diagnostic Trending and Testing Plan

A plan developed by the commissioning provider for control system trend logging, portable data logging, and/or functional testing to gather performance data for systems that are suspected to have operational issues.

Note

Depending on the scope of the project, the investigation can take anywhere from several days to several months to complete.

typically trended include energy (such as electrical energy or demand, gas, steam, or chilled water), operating parameters (such as temperatures, flow rates, and pressures), weather data, and setpoints.

From this collected data, the commissioning provider can calculate key metrics and perform statistical analysis as well as create data plots that show hourly, daily, weekly, or monthly trends, or how one parameter varies with changes in another. By analyzing this information, the commissioning provider characterizes the performance and verifies whether or not the systems are operating correctly.

There are two methods of collecting trend data:

EMCS Trend Logging:

Trend logging (trending) capabilities vary considerably among EMCS systems. The extent of these capabilities will, to a great degree, determine the extent to which trending can be used for diagnostics.

Many facilities may already be doing a considerable amount of trending and data collection; however, deep analysis of the data is rarely in a typical building operator's job description.

If using the EMCS as a diagnostic tool when the controls programming is proprietary, the commissioning provider may require assistance from the controls vendor, particularly in developing, downloading or formatting computer files for analysis. In these cases, the commissioning provider may only be able to go so far with trending and investigation will have to be completed later when the controls contractor is brought in for implementation.

Portable Data logging

Portable data loggers can be an extremely useful diagnostic tool, especially if the EMCS has any limitations in its ability to collect, store, or present data. Portable data loggers are battery-powered, small, light, and easily installed and removed without disrupting building occupants. Many come with sophisticated software packages so that data can be downloaded and easily graphed and analyzed on a

Note

Facility staff can reduce time spent on the diagnostic monitoring and testing by assisting the commissioning provider with tasks such as:

- Completing the calibration
- Assisting with the installation and removal of the data loggers
- Assisting with the trend logging, or developing, downloading or formatting computer files for analysis by the commissioning provider

Definition: Trending Plan

A Trending Plan typically includes:

- Points to be trended
- Value type to be trended
- Sampling rate
- Trend group each point will be analyzed with
- Visual method of analysis to be used

Definition: Data logger

A stand-alone electronic data gathering device that utilizes sensors to collect equipment information over time. Data collected could include temperatures, pressure, current, humidity, or other operation information.

Definition: Data logging Plan

A Data logging Plan typically includes:

- Brand name of data logger
- Run-time parameters
- Start date/time and Stop date/time
- Sampling frequency
- Total loggers
- Total points

By individual logger, the plan also includes: equipment name, point name, measurement, type module, and units.

computer in a variety of ways.

Functional Testing

In most cases, the trend data only indicate a problem, but not the *root cause*. In these cases, or in cases where it is impossible to naturally observe every possible operating regime, the commissioning provider conducts functional performance tests and takes the system through its paces, observing, measuring and recording its performance in all the key operating modes (including both normal and emergency scenarios). The provider develops a well-defined test protocol that describes how the test will be carried out. The commissioning provider and owner schedule the testing and make any necessary preparations, such as checking and calibrating control points or temperature sensors, and then carry out the tests, meticulously recording all their findings on a pre-defined data sheet.

The commissioning provider leads the diagnostic trending and testing, but should utilize the in-house staff to the extent possible. Involving the building operators enhances the retrocommissioning process and is a unique opportunity to deepen their understanding of the systems and controls. Strategically using in-house staff can also reduce the time – and money – spent on this step of the investigation process.

Perform Simple Repairs as the Project Progresses

It is important to note that retrocommissioning is a changeable, iterative process. In some cases, investigation activities may be carried over into the implementation phase as more diagnostics are needed to identify and implement the appropriate fix. This is common when the control system is proprietary and the control contractor is needed for programming or trend analysis that may be essential for diagnostics and implementation.

Conversely, some implementation activities may occur during investigation. Often, completing simple repairs and adjustments discovered during the investigation is necessary to help get to the root cause of a problem

Resource

A library of functional test forms and guidance documents is available in the Functional Testing Guide for Air Handling Systems, available from the CCC on-line library (www.cacx.org).

Sellers, Friedman, Haasl, Bourassa, and Piette. “Functional Testing Guide for Air Handling Systems: From the Fundamentals to the Field” (2003). PIER.

Definition: Functional Testing Plan

A written protocol that describes exactly how a particular test will be carried out. It includes:

- Purpose of the test
- Instructions for carrying out and documenting test
- Equipment required for test
- Acceptance criteria
- Precautions
- Prerequisites for testing
- Detailed procedural steps for testing
- Procedure for returning to normal
- Analysis required
- Required sign-offs

and increases the effectiveness of the diagnostic monitoring and testing. For example, it may be necessary to calibrate a mixed-air temperature sensor before diagnosing economizer problems.

Of course, the commissioning provider should use caution when making even these small fixes and consult first with a building operator. For example, a damper that is supposed to be closed may have been propped open by a building operator as a quick fix to solve a serious IAQ problems, and closing it may be a dangerous solution.

Develop the Master List of Findings

After diagnostic trending and testing is complete and the results are analyzed, the commissioning provider summarizes the findings in the *Master List of Findings* (“Findings Log”). The Findings Log is one of the most significant deliverables from the retrocommissioning process and ultimately becomes an important decision-making tool for the building owner. Every finding from the investigation phase, including the “field fixes” made during the course of the diagnostics, is summarized in the Findings Log. The Findings Log records, at a minimum, a description of the measure, estimated energy savings, cost estimates, simple payback, recommendations for implementation, and status of implementation.

Depending on the owner’s needs, the commissioning provider should consider how to sort and present the Findings Log, perhaps adding specific fields to the list. For example, the owner may have a certain simple payback or return on investment (ROI) criteria upon which their organization makes decisions. Other possible categories for the Findings Log include:

- System type affected (chilled water plant, air handling unit, lighting control, etc.)
- Type of problem (operations, maintenance, design, or installation)
- Non-energy benefits (improved indoor air quality, reduced maintenance, safety, etc.)

Note: M&V for Utility Programs

If the project is receiving funding from a publicly or utility funded program, demonstration of savings may be required in order to receive incentives. Therefore, caution should be taken and no changes should be made while a baseline of performance is being established.

Definition: Master List of Findings

A summary list of findings generated during the investigation process. For each finding, the list contains the following fields: finding description, type of equipment, recommended improvement, estimated energy savings and costs, simple payback, recommendations for implementation, and status of implementation.

Note: Uses of the Master List of Findings/Findings Log

The Master List of Findings serves multiple functions through the investigation and implementation. Common uses are listed below:

- Deliverable and decision-making tool for the owner
- Document for various contractors that may be implementing particular measures
- Ongoing record of the implementation status of the recommended measures (i.e., completed, under consideration, on-hold due to budgetary constraints, etc.)

When compiling the Findings Log, a unique ID number should be assigned to each finding. This number is used as a reference number throughout every retrocommissioning report and document to avoid confusion.

Prioritize and Select Operational Improvements

After the *Master List of Findings* is complete, the commissioning provider presents the results to the owner and assists with selecting measures for implementation.

Depending on the owner's needs and scope of the project, the *Master List of Findings* may be a sufficient decision-making tool to proceed to implementation, as it provides a summary of the investigation findings, recommended solutions, and a cost-benefit analysis. Some owners may wish to have the Findings Log included in an Interim or Summary Report in which the commissioning provider details their findings from the site assessment, building documentation review, and diagnostic trending and testing. In any case, the owner should require the provider to supply all calculations and assumptions behind their energy savings and cost estimates.

To the extent needed, the commissioning provider should assist the owner with selecting measures for implementation. This process may take some time, as there are many factors to be taken into account before implementation begins, including the capability and availability of in-house staff to implement measures, and the availability of in-house funds or funding from outside sources such as utility programs.

Note

Many typical findings that result from retrocommissioning can provide less than one-year paybacks, especially if some of the implementation work can be accomplished by in-house staff. Any organization should be able to justify funding for such measures.

Implementation

How implementation is carried out varies greatly among projects: each building will require different types of measures, each owner is faced with unique budgetary and administrative situations, and each building staff will have different capabilities and contractor relationships.

Retaining the commissioning provider through the implementation phase is highly recommended, even if the implementation work is done in-house or outsourced to another contractor. Because the provider has an intimate knowledge of the building systems and needed improvements, having him or her oversee the implementation may ultimately save time and reduce costs.

The following are considerations for implementation phase activities.

Select an Approach for Implementation

The owner must first choose an approach for implementing the recommended measures. Choosing an approach largely depends on the in-house building staff's expertise and availability, as well as the owner's willingness to manage the implementation activities. There are three common approaches to implementation as part of a retrocommissioning project:

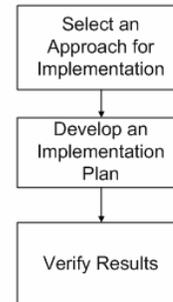
- Turn-key implementation by the commissioning provider
- Commissioning provider assistance in implementation
- Owner-led implementation

Each of these approaches is discussed below.

Turn-key Implementation

In many instances, the commissioning provider can complete the project for the owner and perform most, if not all, implementation activities. There are many advantages for the owner with the turn-key approach; primarily that the owner holds only one contract for implementation and any subcontracts are held and

Implementation Phase Retrocommissioning Process



Implementation Phase Deliverables

- Implementation Plan

managed by the commissioning provider. Also, the commissioning provider has the deepest insight into the building or system's operation at that point, and is best suited to addressing the issues. This is often the easiest option for the owner, as it reduces their time spent coordinating, contracting and managing implementation activities.

Commissioning Provider Assistance in Implementation

Under this approach, the commissioning provider is retained to provide assistance and oversight through implementation. This approach is ideal when in-house staff is highly skilled and can carry out much of the work, or when the specialized skills of contractors are required. When contractors are used, it is most likely that the owner will still hold a contract or open purchase order with the commissioning provider to provide assistance, and then hire service or control contractors as needed for implementing particular measures. The commissioning provider can help the owner define the scope of work for both in-house staff and contractors and verify that the results meet expectations.

Owner-led Implementation

The owner can also choose to take the results and recommendations from the investigation and proceed to implementation without further assistance from the commissioning provider. This option may be attractive to owners who have strong, established relationships with a service contractor or a highly-capable in-house engineer who can implement and verify the measures. Note that even in this case, the commissioning provider will still conduct the tasks outlined in the hand-off phase section that follows.

Develop an Implementation Plan

An *Implementation Plan* organizes and defines the work needed to obtain the required results. Primarily, the *Implementation Plan* includes a scope of work for addressing each issue that the owner has selected along with requirements for verification. Depending on what post-implementation data the owner needs, either for internal purposes or for receiving incentives from an outside program, the plan also recommends

Note

If hiring the commissioning provider to provide implementation assistance, a second contract will likely need to be drawn up, as the scope for implementation is difficult to ascertain at the beginning of the project.

methods for calculating energy savings and verifying the performance of the measures after implementation.

Depending on the approach to implementation, the *Implementation Plan* is a guideline for building staff for making the repairs and improvements, or it is used to gather scopes of work and bids from contractors. If the commissioning provider is providing turn-key implementation, the plan may take the shape of a proposal and scope of work for the provider to perform all implementation and verification activities.

Verify Results

Once an improvement is completed, it is important to retest the equipment or systems to ensure that the improvements are working as expected. Retesting can be done with EMCS trending, data logging, functional testing, simple observation, or a combination of these methods. For example, retesting might involve manually testing the repaired items such as damper motors or valves to verify that they stroke properly, followed by trending or data logging to determine that they are modulating to maintain the desired setpoint at the appropriate times.

In order to confirm that the combination of improvements are integrated and have the desired effect for the building, the post-implementation data is compared to the original, baseline data. The commissioning provider also uses this verification data to update the energy savings estimates as needed.

This data can also be used to establish a new baseline for the performance of the building systems. This baseline can then be used to establish criteria or parameters for tracking whether or not the improvements are performing properly throughout the life of the equipment or systems.

Definition: Implementation Plan

A document prepared by the commissioning provider to provide guidance or a scope of work for implementing measures identified during the investigation.

Hand-off

Project hand-off is the final phase of a retrocommissioning project. To ensure that the building owner and operators have what they need to monitor and maintain the implemented measures, an intentional and thorough project hand-off is essential.

Develop the Final Report

The Final Report is intended as a record of the retrocommissioning activities and measures that were implemented. It is critical to long-term persistence of savings because it contains recommendations for O&M practices that will maintain the performance of the improved systems. It is a resource for current and future operators and should be made part of the permanent record of recommended O&M practices at the building.

Provide Training

Training for building staff should occur throughout the project, and involving them from the start gives staff the best opportunity to learn about new or existing building systems and equipment and sequences. At project hand-off, it is ideal for the commissioning provider to provide any additional training needed on the implemented measures, as well as address other areas of building operation that are of particular concern to the owner.

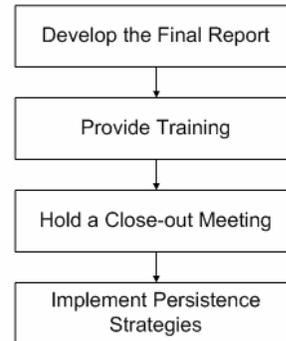
Hold a Close-out Meeting

After the commissioning provider has completed the Final Report, it is recommended that a project close-out meeting be held with the entire retrocommissioning team. This meeting is valuable for discussing the lessons learned during the project, and provides an important opportunity to recognize individual successes and celebrate the overall success of the project.

Implement Persistence Strategies

Immediately after the retrocommissioning measures

Hand-off Phase Retrocommissioning Process



Hand-off Phase Deliverables

- Final Report

Definition: Final Report

The Final Report is a summary of the project and provides a record of the retrocommissioning activities and recommendations for monitoring and maintaining the implemented measures. The contents of the Final Report include:

- Executive summary
- Project background
- The Master List of Findings, with a description of the improvements implemented
- A cost/benefits analysis for the estimates of savings and the actual improvement costs for each improvement implemented
- The EMCS trending plan and logger diagnostic / monitoring plan and annotated results
- All completed functional tests and results
- Recommended frequency for recommissioning by equipment type with reference to tests conducted during initial retrocommissioning

are implemented, maximum savings can be realized and the treated systems are operating at their peak performance. Over time, however, the efficiency of the systems may decline, unless explicit strategies are put into place to maintain and monitor the improvements.

The owner should consider implementing one or more strategies that help to ensure that the energy savings – and other benefits – from the retrocommissioning project are long-lasting. Common strategies for ensuring persistence include:

- Providing complete documentation of the retrocommissioning process, and updating building documents as needed.
- Providing training for building staff.
- Enhancing the current preventive maintenance program to include operations.
- Tracking building performance.
- Periodically recommissioning the building.
- Instituting a plan of “continuous” or “monitoring-based commissioning

- Complete documentation of revised or new strategies adopted to optimize systems operation
- A list of capital improvements recommended for further investigation

Cross Reference

Chapter 5: Strategies for Ensuring Persistence of Savings covers each of these in full.

Integrating Commissioning with Building Retrofits

The term “retrocommissioning” can be used either to mean the commissioning of an existing building or the commissioning of a retrofit project. This ambiguity reflects a complex spectrum of possible scenarios, in which commissioning is combined with other building improvements. While an analyst may prefer that these activities be kept as separate as possible, it is highly likely that a building owner will desire to make a range of different improvements at the same time, so these scenarios should be addressed.

Commissioning of a Retrofit Project

The primary objective of commissioning during a retrofit project is to confirm that the new equipment being installed – and the existing building systems with which it interacts – are operating as intended. This confirmation is particularly important for mechanical equipment and controls, because their improper operation can influence performance and reduce the energy efficiency of related systems.

The process of commissioning of retrofits is a hybrid of the processes for new and existing buildings. In new buildings, the commissioning process includes definition of the owner’s project requirements, review of the design drawings and specifications, review of submittals, inspection of installed equipment, functional testing of systems, training, and documentation. All of these are required in the construction of a retrofit. However, when new equipment is integrated with existing equipment, as in the case of an energy retrofit project, the commissioning provider will emphasize methods that are more common in commissioning of existing buildings, such as the definition of *current* operational requirements, and trending. The commissioning provider’s responsibilities may expand to include the following tasks related to commissioning the retrofit project:

- Develop commissioning specifications for the new equipment.
- Develop a commissioning plan specifically addressing the new equipment.
- Oversee the commissioning of the retrofit project, including the delivery of specified staff training and system documentation.
- Perform short-term diagnostic monitoring of existing systems and the new equipment to ensure that they are properly integrated.
- Develop and oversee prefunctional checklists and manual functional test procedures as needed on the new equipment.
- Develop separate Master Lists of deficiencies for the new equipment.
- Ensure that the identified deficiencies for the new equipment are resolved to the owner’s satisfaction.

Tuning a Building Prior to a Retrofit

The main intent of retrocommissioning is to improve and optimize the operation of building systems. It is not a method for keeping old, inefficient equipment limping along.

When considering retrocommissioning, evaluate the equipment and the building systems to determine how many of them will need replacing within the next year or two. Investing

in retrocommissioning of equipment or systems that will be replaced shortly after project completion is obviously not a good investment. However, it is also true that a retrofit will be most cost effective if the building it is applied to is performing optimally. For example, before replacing a chiller with a more efficient model, one may be able to downsize the replacement chiller by making sure that the loads in the building are reduced and that there are no operational problems such as coincident heating and cooling that may artificially require a higher chiller capacity. For buildings with newer equipment (less than 12 years old), retrocommissioning may be the most appropriate first step for optimizing building performance and obtaining cost savings.

Retrofits Identified During Retrocommissioning

Many of the improvement opportunities identified during retrocommissioning will require more than a quick fix. In some cases, retrocommissioning will result in the recommendation for an equipment retrofit. This recommendation can be implemented at a later time, or it can be implemented within the boundaries of the retrocommissioning project, depending on how the commissioning provider's contract scope is defined.

There are advantages to having the commissioning provider involved in the retrofit. The provider has the best information about how the system is currently operating, and will be able to provide assistance in the design or specification of the retrofit. The commissioning provider will be able to conduct the necessary performance tests to verify system performance after the installation of the retrofit.

Retrocommissioning in ESPC or Publicly-Funded Programs

When retrocommissioning is provided along with retrofits under an Energy Savings Performance Contract (ESPC) or in a utility or other publicly-funded program, it may be necessary to clearly delineate which activity is responsible for the savings: the commissioning or the retrofit? This is quite difficult to do, and is often ambiguous. The commissioning provider might rightly claim credit for identifying retrofits, participating in the retrofits, and commissioning the retrofits, although the retrofit provider will also claim full credit for the performance of the retrofit. Although this kind of accounting is difficult to do, it should not be a barrier to conducting both activities as there is such a significant synergy in conducting them together.

4. The Commissioning Team

Retrocommissioning is a team effort and, depending on the scope and complexity of the project, many individuals may be brought in to participate. Assembling the commissioning team is usually the first, and one of the most important, parts of kicking off a retrocommissioning project. This chapter discusses:

- Who should be on the retrocommissioning team, and how responsibilities are usually assigned
- The typical roles and responsibilities of the retrocommissioning team members
- The commissioning provider selection process
- How to evaluate commissioning provider qualifications

Online Resources

www.bcxa.org

Building Commissioning Association

Membership Directory Search allows user to search for BCA member commissioning providers in a specific state or region.

www.cacx.org

California Commissioning Collaborative

Contains a collection of resources to help owners select a commissioning provider, including recommended qualifications, comparison of provider certification programs and a list of providers doing business in California.

Publications

Haasl, Tudi and Robert Bahl, E.J. Hilts, and David Sellers. *Appropriate Use of Third Parties in the Existing Building Commissioning Process – An In-house Approach to Retrocommissioning* (2004). World Energy Engineering Congress.

Building the Retrocommissioning Team

The make-up of the retrocommissioning team depends largely on the scope and budget of the project, the complexity of building systems, and the expertise and availability of in-house building staff.

The first challenge is to assemble a team that best matches the size and complexity of the project. To do this, the owner must ask:

- *What are the objectives of the project?*
- *What are the skills and depth of experience of my current O&M staff?*
- *Do I have staff members who have participated in any type of commissioning process before?*
- *Are they currently available to take on additional work? Can time be made in their schedules for this project?*
- *Can I get the funds to hire an outside commissioning provider?*

Upon answering these questions, the building owner decides upon an approach for the project and determines who will perform most of the retro-commissioning work: a third-party commissioning provider or in-house staff.

In most cases, the owner chooses to hire a third-party independent commissioning provider or consultant to lead and manage the retrocommissioning project.

Some good reasons to bring in a third-party commissioning provider include:

- The owner or manager may not have the time or staff resources to participate in the process, or the in-house skills to perform the in-depth assessment that is required during the retrocommissioning process.
- Consultants specializing in commissioning and O&M services have vast experience to draw upon, enabling them to offer a fresh and different perspective on your building. A third-party provider has no preconceived notions about how the building should perform, and has no vested

Cross Reference

In *Chapter 3: The Retrocommissioning Process*, there is a specific discussion on various approaches to implementation on page **XX**.

interests in maintaining the status quo.

- A commissioning provider is “tooled” for performing the work since they likely regularly use data loggers, functional test forms, power monitors, etc. Most have proven assessment and testing procedures that can be customized to fit your building.
- Engineering analysis is the specialty of a commissioning provider, who has the analytical skills and resources needed to diagnose hidden problems and determine the cost-effectiveness of selected improvements. Retrocommissioning requires a “forensic” personality and a curiosity about how things work. Most retrocommissioning providers have this personality.

While there are some cases when it is very appropriate for the building staff to play a central role in a retro-commissioning project, having a commissioning expert provide some level of consultation is recommended, especially for large or complex projects and buildings with highly-integrated, sophisticated systems.

Four approaches for using a third-party commissioning provider include:

1. *Hire a commissioning provider to oversee and implement the retrocommissioning process through all phases.* This “turn-key” approach often works well for owners who have one or more buildings with no O&M staff, or minimal staff with little time or training. The provider leads the project, manages any necessary subcontracts, and is solely responsible for ensuring that the owner’s goals and expectations are being met through each phase of the process.
2. *Hire a commissioning provider to lead the process, but divide the assessment work, to the extent possible, with O&M staff.* This arrangement works particularly well when members of the owner’s staff have previous experience in commissioning, or have an expert level knowledge of building systems. Arrangements such as these should be considered an ‘active partnership’

between the facility staff and the commissioning provider, leveraging in-house expertise as much as possible through all phases of the process to reduce consulting costs.

3. *Hire a commissioning provider to work closely with in-house staff on initial projects, with the intention of the in-house staff to independently proceeding with future projects.* Owners with multiple buildings and well-trained and available O&M staff may want to hire a commissioning provider to work with the building staff for the first one or two buildings that undergo retrocommissioning. After the building staff is trained in the process, they can proceed with the rest of the buildings, acting as the commissioning provider.
4. *Hire a commissioning provider to work closely with in-house staff on initial projects, and retain the consultant to perform advanced tasks on future projects.* This is similar to the third approach in that in-house staff work to take on the role of the commissioning provider. However, in this approach the third-party commissioning consultant is retained for future projects to oversee critical parts of the assessment or advanced tasks such as functional testing, data analysis, and savings estimates and calculations.

Example: Marriott Retrocommissioning (MRCx) Program

The Marriott International MRCx Program applies an approach they call “minimum use of third parties for the maximum benefit.” Under this model, they manage the process, the “facility staff is in the driver seat,” and third-party assistance is engaged strategically through the process.

The in-house facility team’s tasks typically include:

- Data gathering
- Utility bill analysis and benchmarking
- Assisting the commissioning provider with monitoring and testing
- Performing easy-to-fix O&M work
- Ongoing tracking of benefits

The provider is hired as needed to assist with advanced tasks such as:

- Diagnostic trending and testing
- Identification of the root cause of problems
- Data analysis
- Development of systems drawings

Implementation of measures that are beyond the staff’s expertise may be done by service or control contractors. Even when these third-party services are engaged, the facility staff remains closely involved in the process as part of their training and take on more of the retrocommissioning tasks over time.

Haasl, Tudi and Robert Bahl, E.J. Hiltz, and David Sellers. *Appropriate Use of Third Parties in the Existing Building Commissioning Process – An In-house Approach to Retrocommissioning* (2004). World Energy Engineering Congress.

Retrocommissioning Team Members and Their Responsibilities

No matter which approach is selected, assembling the appropriate team and clearly defining and documenting the responsibilities of each team member are vital to the success of the project.

Roles and responsibilities are usually laid out at a project kick-off meeting. All team members should be required to attend, as project scope, process, and schedule are all discussed at this meeting.

Possible team roles are outlined below. Of course, who fulfills the role and what their responsibilities are will vary greatly project-by-project.

Building Owner or Owner's Representative

The owner makes crucial contributions to the success of any retrocommissioning process. Their primary responsibilities are to support the team, provide information and resources needed for the project, and clearly communicate goals and expectations.

The “owner” can be represented by any upper level manager vested in the project, a director or chief of engineering, or the building or facilities manager. In any case, the owner's representative should be an active “champion” who is involved through the project, garners the necessary senior management support, and ensures that the project moves forward. It is very important for the owner to be a strong advocate for the retrocommissioning project. The owner's support enables the retrocommissioning process to proceed more smoothly, correct more building problems and thus produce greater benefits.

In addition, the owner affirms the roles and responsibilities of the retrocommissioning team, and guides the process by clearly articulating the project's expectations. These expectations should be well-documented because they serve as the foundation not only for retrocommissioning but for almost every decision to be made during the process.

Note: Possible Members of the Retrocommissioning Team

- Building owner or owner's representative
- Commissioning provider
- Building manager and O&M staff
- Contractors or manufacturers' representatives
- Testing specialists
- Design professionals
- LEED coordinator

Note: Primary Building Owner Responsibilities

- Develop and clearly articulate project objectives
- Build and support the retrocommissioning team
- Develop a scope of work
- Provide information and resources needed
- Hire the commissioning provider

Before hiring the commissioning provider, the owner or manager outlines a brief scope of work. A scope of work outline includes:

- The project objectives
- The buildings, building systems, and equipment that will be part of the assessment
- The anticipated level involvement from in-house staff in the process
- The timeframe for investigation completion
- The number and type of expected deliverables or work products resulting from the process

The owner is also responsible for hiring the commissioning provider. The next section in this chapter discusses the methods for doing this.

Commissioning Provider

Whether third-party or in-house, the commissioning provider's tasks and responsibilities depend greatly on the scope of the project, its budget, and the skill of the building O&M staff. Depending on the approach the owner has chosen, the commissioning provider tasks may include:

- Develop the *Retrocommissioning Plan*.
- Facilitate the project kick-off meeting.
- Review existing building documentation, including the *Owner's Operating Requirements*.
- Perform a detailed on-site assessment of the current O&M practices, documenting findings and potential improvements in the *Master List of Findings*.
- Develop monitoring and testing plans.
- Perform short-term diagnostic monitoring, using EMCS trend logging where appropriate.
- Develop, perform, document, and oversee functional test procedures, as needed.
- Estimate energy savings and assist the owner with prioritizing the most cost-effective improvements for implementation.
- Assist with or oversee implementation of the

Cross Reference

Chapter 3: Retrocommissioning Process provides a list of deliverables for each phase of the retro-commissioning process.

Cross Reference

When commissioning of new equipment is integrated with a retro-commissioning project, the commissioning provider's scope of work may expand to include the new equipment installation. *Integrating Commissioning with Building Retrofits*, pages 37-38, provides a list of likely tasks that the commissioning provider may take on in this case.

Note

Depending on the inclusion of explicit persistence strategies in the scope of work, the provider may be asked to fulfill additional tasks, including:

- Review current service contracts and make recommendations for improvements
- Update or create building documentation, such as written sequences of operation for treated

<p>selected improvements.</p> <ul style="list-style-type: none"> • Perform post-installation monitoring and testing activities, as needed. • If needed, recalculate the energy savings based on the before-and-after short-term energy measurements. • Submit the <i>Final Report</i>. • Provide building operator training, as needed, on the implemented measures. <p>As previously discussed, the commissioning provider role can be fulfilled by a third-party consultant or in-house staff. In few cases, the role could even be played by a service contractor who has a long history with the building. Regardless, the individual should be someone able to look at the building with fresh eyes, and without a vested interest in defending the status quo.</p> <p>Building Staff</p> <p>The building staff can both contribute to and benefit from the commissioning process. In order to realize these benefits, however, building staff must be brought into the process as early as possible.</p> <p>Building operator commitment to the retro-commissioning effort is essential, and as retro-commissioning is meant to enhance the overall O&M program and positively support its work – it should not be viewed as a fault-finding, make-work exercise. Staff support can be obtained by including O&M personnel when defining the goals of the project.</p> <p>By participating in the retrocommissioning process, building staff will gain a better understanding of the building’s systems and their interactions. Observing diagnostic trending and testing will also improve the staff’s understanding of equipment and control strategies.</p> <p>Building operators should assist with, or at least observe, as much of the retrocommissioning process as possible in order to improve their understanding of the equipment and control strategies. This knowledge will enable them to retest or recommission systems</p>	<p>equipment and systems</p> <ul style="list-style-type: none"> • Develop a comprehensive training plan for O&M staff • Develop methods for the owner and building staff to track the performance of the improvements • Develop a Recommissioning plan for the facility <p>See <i>Chapter 5: Strategies for Ensuring Persistence of Savings</i>.</p> <p>Note: Primary Building Staff Responsibilities</p> <ul style="list-style-type: none"> • Gather building documentation. • Perform appropriate preventive maintenance tasks prior to starting the investigation. • Calibrate critical sensors • Initiate trending of key variables • Conduct or observe diagnostic monitoring and functional tests. • Perform simple repairs and improvements. • Track measures after implementation. • Provide information to commissioning provider, and remove roadblocks. <p>Cross Reference</p> <p>These primary tasks are discussed in detail in <i>Chapter 2: Benefits and Costs of Retrocommissioning</i>, as tasks the building staff can undertake to help reduce overall costs of the project.</p>
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periodically as part of their ongoing O&M program.

Contractors and Manufacturers’ Representatives

Installing contractors, maintenance service contractors, controls contractors and manufacturers’ representatives are important members of the retro-commissioning team when equipment is relatively new, still under warranty, or under contract for service. In some cases, one firm may have installed the system as a manufacturer’s representative and also hold the service contract for the system. This is often true for control systems and large plant equipment such as chillers and boilers.

Installing contractors and manufacturer representatives may be needed in a retrocommissioning project for equipment testing and/or implementation of measures that pertain to the equipment they installed. If equipment is still under warranty, it is especially important that the responsible company or individual be brought in *early* in the retrocommissioning process, as the warranty may become void if someone else manipulates the equipment.

Some owners do not have full- or part-time building operators, and some may employ building operators with minimal skills or time available. These owners often use service contracts to cover the O&M of the HVAC, controls and electrical systems. In these cases, the service contractor may take on retrocommissioning tasks that building operators would usually perform. The contractor may be requested to perform certain scheduled preventive maintenance tasks to coincide with the needs of the retrocommissioning project, as well as assist in data gathering, performing hands-on testing, and adjusting and calibrating equipment.

The controls contractor will be an essential player on the retrocommissioning team when he or she is the person most familiar with the building’s control sequences and programming, and is needed to perform trend logging and EMCS programming tasks. Having a control technician’s expertise on hand can enhance the potential for improved control strategies for the building, although enlisting the time of a control

Note: Contractors that may be part of the Retrocommissioning Team

- Installing contractors
- Manufacturers’ representatives
- Maintenance service contractors
- Controls contractors

Note: Primary Contractor and Manufacturers’ Representative Responsibilities

- Perform or assist with testing of the system they installed and/or currently service
- Implement measures found during the retrocommissioning investigation that are relevant to the system they installed and/or currently service

technician may be expensive.

Testing Specialists

Some commissioning providers are also test engineers and thus fully-equipped to perform almost any test required. However, this may not always be the case. Many providers are skilled at performing HVAC functional tests and calibration exercises, but rely on other professionals or test experts for more complicated testing or for equipment that requires special expertise, such as variable-volume fume hoods. In these cases, the commissioning provider typically writes the test procedures and the testing is then completed by the appropriate specialist.

Design Professionals

The involvement of design professionals in the retro-commissioning process depends on the age of the equipment, the systems involved and whether new installation is occurring during the retro-commissioning process. When retrocommissioning coincides with a new installation, the designer of the equipment should be part of the team.

The other instance in which design professionals are involved is if the commissioning provider needs additional expertise regarding design issues that are uncovered during investigation. In such cases, a design professional (ideally, the engineer who designed the original installation) may be brought on the team as a consultant to help resolve the issues.

LEED Coordinator

The LEED Coordinator works closely with the project team to track and document everything that must be done in order for the project to achieve the desired certification level including what, when and by whom environmental measures are implemented. The LEED coordinator's role requires managing a multitude of complex details that are unique to LEED-EB projects and the LEED rating system. These responsibilities overlap with those of the commissioning provider, but are also very different. The responsibilities of these two roles are almost always too great for a single individual.

Selecting a Third-Party Commissioning Provider

Because every project is unique, it is important to select a commissioning provider whose expertise and experience closely match the project's objectives, scope, and complexity.

The two key steps for selecting a third-party commissioning provider are discussed below.

Commissioning Provider Selection Process

There are two primary methods for selecting a commissioning provider: competitive bid and selection by qualification.

Competitive Bid

If the project is large or fairly complex, it may be most appropriate to select the provider through a competitive bid process. A competitive bid selection process is one in which the owner issues a Request for Proposals (RFP). This process can be time-consuming and expensive, as it solicits qualifications and a detailed scope of work from the commissioning provider and requires the owner to carefully evaluate each submission. Many public agencies are required to go with the lowest qualified bidder. In these cases, it is very important to define the minimum qualifications carefully.

Selection by Qualification

Selection by qualification can be used on any project where an RFP process is not required. In this case, the provider is selected based on qualifications and rate schedule, supplied as a response to a Request for Qualifications (RFQ). Although this process is often simpler than the competitive bid process, it does require the owner to carefully evaluate the providers' qualifications and interview past clients and references. This process allows the owner to select the most qualified provider regardless of cost.

Note: Resources

The California Commissioning Collaborative (CCC) Web site, www.cacx.org, provides an RFP checklist for owners to use, as well as sample RFPs.

Evaluating Commissioning Provider Qualifications

Intuitively, the scope of the project determines the qualifications one looks for in a commissioning provider: the more complex the project, the more experience is required of the commissioning provider. On projects with special or mission-critical needs, such as hospitals or laboratories, it is particularly important to select a commissioning provider with directly relevant experience.

Recommended Provider Qualifications

Individual projects may require a commissioning provider with more, less or different experiences than those described below. This list is by no means all-inclusive.

Technical knowledge

In all retrocommissioning projects, the commissioning provider should have experience and up-to-date technical knowledge in the related fields of design, construction and building operations. The provider should also have extensive and recent hands-on field experience in all aspects of the retrocommissioning process.

The commissioning provider can employ or partner with technology specialists who have expertise in systems with which the provider is not experienced. However, the HVAC and controls systems are so central to retrocommissioning that the commissioning provider should have a good technical knowledge of the fundamentals, design, and operation of the HVAC system and the implementation of controls systems.

Relevant experience

The commissioning provider must have experience troubleshooting. In more complex projects, the provider should have at least five years' experience.

The provider should have served in a similar capacity on at least two other projects with similar needs. In a more complex project, the commissioning provider should have experience on at least four similar projects.

Note: Resources

The California Commissioning Collaborative (CCC) Web site, www.cacx.org, is an excellent resource in evaluating provider qualifications.

Note

When evaluating commissioning provider qualifications, owners should follow the following steps:

1. Evaluate the provider's technical knowledge and experience with similar building systems and problems
2. Evaluate the provider's non-technical skills
3. Establish whether commissioning is one of the individual or firm's core services
4. Request and contact references
5. Request and review sample work products

Non-technical skills

The provider should have excellent written, verbal, organizational, and conflict resolution skills.

References and sample work products

The commissioning provider should provide references and work products from other, similar commissioning projects.

Finding a Third-Party Commissioning Provider

The California Commissioning Collaborative provides a comprehensive and up-to-date comparison of available commissioning provider certification programs as well as a list of current providers in the State of California for new construction and existing building commissioning. Their Web site, www.cacx.org, is a great resource for finding a provider for your project.

5. Strategies for Ensuring Persistence of Benefits

At the end of the retrocommissioning process, the treated systems are well tuned and operating at their peak performance. However, buildings change over time and, unless explicit strategies are put into place to maintain and monitor the improvements, the efficiency of the systems may decline. What can you do to ensure the benefits from retrocommissioning persist?

Successful persistence planning begins early in the retrocommissioning process and enhances current O&M practices. The following are key strategies that can make the difference between retrocommissioning benefits that are short-lived and those that endure over the long-term:

- Providing complete documentation of the retrocommissioning process, and updating building documents as needed
- Providing training for building staff or service contractors
- Enhancing the current preventive maintenance program or service contracts to include any new O&M measures that result from the retrocommissioning activities
- Tracking building performance
- Periodically recommissioning the building
- Institute a program of “continuous” or “monitoring-based” commissioning

Online Resources

Publications

U.S. Department of Energy/PIER. *Strategies for Improving Persistence of Commissioning Benefits* (2003).

O&M Best Practices series (1999). US EPA/US DOE.

Sellers, David. *Using Utility Bills and Average Daily Consumption to Target Commissioning Efforts and Track Building Performance* (2001). International Conference on Enhanced Building Operations.

Building Documentation

Thorough, accessible documentation helps ensure that the benefits of retro-commissioning persist. Without a good record of the knowledge gained from the process, much of the long-term value may be lost.

The *Final Report* from the retrocommissioning process becomes an important document for the building and an invaluable resource to current and future building operators. In addition to requiring a *Final Report*, building owners and managers should consider the task of creating or updating essential building documentation as part of the retro-commissioning scope.

At first glance, spending money on documentation may seem like an “extra.” However, these documents supply building operators as well as HVAC, controls or maintenance service contractors with the information they need to maintain systems and equipment, troubleshoot problems, and monitor the measures that were implemented.

A good time to create documents for an existing building that does not have complete or up-to-date documentation is during a retrofit or a retro-commissioning project, as operational or equipment changes have just been made and there is momentum and focus on improving system operations.

Starting to assemble or recreate building documents from scratch years after construction has ended and when most of the responsible parties are long gone can be difficult and expensive. But the process is important, as it helps those tasked with operations and maintenance gain a better understanding of the facility and have the resources they need to maintain systems and troubleshoot problems.

There are a few essential documents that should be updated (or created, if necessary) as part of a retro-commissioning project, including:

Definition: Systems Manuals

A *Systems Manual* is a compilation of important building documentation. There are a variety of ways to put together a *Systems Manual* – the important thing is that the essential information about how to operate the building is included, as well as the lessons learned from the retrocommissioning process.

ASHRAE Guideline 0 (2005) defines a *Systems Manual* as “a system-focused composite document that includes the operation manual, maintenance manual, and additional information of use to the Owner during the Occupancy and Operations Phase.”

- Equipment Lists
- O&M Manuals
- Control System Documents
- Systems Diagrams

A brief overview of each is below.

Equipment Lists

It is important to have equipment lists for the building's main energy consuming systems and equipment, including: controls, HVAC, terminal equipment, duct and piping fabrication, and electrical systems. Typically, the lists contain the following information for each piece of equipment:

- Unique equipment identification number
- Nameplate information
- Manufacturer's name
- Vendor's name and contact information
- Equipment location
- Date installed

O&M Manuals

In general, O&M manuals must be detailed enough to help building staff operate, maintain and troubleshoot equipment. At a minimum, they typically include:

- Performance curves (for pumps, chillers, fans, etc.)
- Operation requirements
- Preventive maintenance requirements
- Parts lists
- Start-up procedures
- Troubleshooting procedures

If a building has good, current O&M manuals, then they only need to be updated to include any changes to equipment or operations that are made as part of the retrocommissioning project. If the existing O&M manuals are not complete enough to support effective O&M of the existing equipment, the owner should consider including a task in the retrocommissioning scope to improve them.

Control System Documents

Points Lists

Both for control and monitoring purposes, it is helpful to have a full and complete points list that includes all the input and output points in the DDC system. This list should include information such as the point name (adhering to a consistent and clear naming convention), point type, sensor or actuator type, accuracy, name and type of the associated component, the panel in which it is attached, alarm limits, and trending frequency. A system diagram showing the actual location of the points is essential (see below).

Documenting the trending procedures and capabilities helps to streamline trending and can avoid hours of frustration trying to match point names to their locations. Any changes made to the control system as part of the retrocommissioning process should be recorded accurately and promptly.

Sequences of Operation

Sequences of operation help building staff understand how the control system should operate. At a minimum, a detailed sequence of operations should be created for each HVAC and lighting system.

After a retrocommissioning project, any changes to the sequences should be carefully documented, and the reasons for all changes should be described in detail. Improvements are more likely to persist when operators understand the rationale for the changes and agree with their implementation. Any control sequences that were not affected by the retrocommissioning project yet are found to be incorrect or poorly specified, should be corrected as a part of the retrocommissioning project.

Systems Diagrams

A system diagram enables the user to see the entire process of heating, cooling, and ventilation of spaces and visualize potential interactions. It depicts the entire system in schematic format, rather than simply showing pieces of the system.

Example: Sequences of Operation

The commissioning provider may choose to develop a system diagram during the inspection of the facility, and compare it with other diagrams that were previously produced. A system diagram laid out in the simplest way possible goes a long way in clarifying the intended operation of the entire system, and helping to identify errors in the construction or assembly of the system. On projects where a system diagram does not exist, developing one is a good first step. Once completed, the system diagram serves as the schematic on system documentation and can be incorporated into the DDC terminal interface.

Example: Systems Diagrams

A well-developed air handling system diagram includes the following features:

- The system's complete airflow path is shown, from point of entry into the building to point of exit.
- All significant components are labeled, including dampers, coils, filters, fans and all final control elements and sensors.
- Equipment operating parameters are stated, including flow ratings, horsepower ratings and other pertinent operating data.

Building Staff Training

Training is perhaps the most essential factor in good O&M practices. Unless operators and managers have the right knowledge and skills, it will be impossible for the building to perform optimally over the long-term.

Building operating staff should be involved in all phases of the retrocommissioning process, starting during planning. Shadowing the provider and assisting throughout the process provides invaluable on-the-job training. At the end, the entire building staff should understand the measures that were implemented and participate in a training session at hand-off that covers any new documentation and key methods for monitoring and maintaining the improvements.

A well designed training plan supported by comprehensive building documentation and videotapes of the training sessions will help ensure that the building is operated efficiently and that the benefits associated with the retrocommissioning process persist for the life of the building.

Perhaps the most common area for improvement in building operator training lies in the trending and alarming functions of the DDC system. The wide gap between the capabilities of these complex systems and the ability of building operators to fully utilize them leads to missed opportunities every day, in both the early identification of building problems and significant energy savings. For example, trends and alarms can be set in the DDC system by the controls contractor or commissioning provider, but unless staff are trained on how to look at the data and review alarm logs, then the owner isn't getting the most out of their system.

Ongoing Training

Building operators should be encouraged to increase their knowledge and enhance their job skills by taking readily available training courses offered by utility energy centers, training organizations, and equipment manufacturers. In addition, a system should be in place

Note: Recommended Hand-off Training Topics

- Energy Usage Analysis
- Operating Schedules & Owner's Operating Requirements
- Investigation process & methods used to identify problems and deficiencies
- Master List of Findings
- Measures that were implemented and by whom
- Describe improved performance that these measures will create (show trends if available)
- O&M requirements needed to keep these improvements working
- Staff role in helping to maintain the persistence of savings

As part of hand-off, it is also useful to walk around the building to look at any physical changes or step through the new control sequences at the operator workstation.

to transfer information to new operators as they come on board. As part of their orientation, a new operator should shadow an existing building operator through an in-depth building walk-through as well as review existing building documentation, which illustrates the importance of having up-to-date documents. A well-executed hand-off will go a long way toward ensuring efficient building performance.

Note: Ongoing Training Opportunities

Building Operator Certification

The BOC's competency-based trainings are designed specifically to help building operators improve their ability to operate and maintain comfortable, efficient facilities.

BOC courses are offered at two skill levels and cover several topics, including electrical, HVAC and lighting systems, indoor air quality, environmental health and safety, and energy conservation. Classes are usually a combination of lecture, discussion and small group activities. BOC classes are held continuously, at locations across California.

Course schedules and descriptions are available at the BOC Web site: www.theboc.org

Pacific Gas & Electric

Pacific Energy Center (PEC)
San Francisco
www.pge.com

Sacramento Municipal Utility District

SMUD Customer Service Center
Sacramento
www.smud.org

Southern California Edison

Customer Technology Application Center (CTAC)
Irwindale
www.sce.com

Preventive Operations & Maintenance

Redefining preventive maintenance to include operational activities is a critical strategy for long-term energy-efficient performance.

Typically, the primary goal of a preventive maintenance (PM) program is to improve reliability and increase equipment life. In many buildings, staff implement rigorous maintenance-focused programs. However, even when equipment is meticulously maintained, operation that relies on inadequate control strategies or improper scheduling can result in significant energy waste, equipment failures, reduction in the useful life of equipment, and poor indoor air quality.

Owners can enhance PM goals by incorporating procedures that promote efficient operation, empowering staff to take steps to maintain optimization and supporting them with good documentation and training.

Incorporating Operations into Your Maintenance Plan

A typical PM plan consists of a checklist of maintenance tasks and a schedule for performing them. The checklists are kept for each piece of equipment and updated after maintenance tasks are performed. Incorporating operations into the current maintenance plan entails similar rigor for recording setpoints, settings, and parameters for the control strategies. It also means that operators regularly review and update the owner's operating requirements as occupancy or operational changes are made, and continuously ask questions such as:

- *Have occupancy patterns or space layouts changed?*
- *Have temporary occupancy schedules been returned to original settings?*
- *Have altered equipment schedules or lockouts been returned to original settings?*
- *Is equipment short-cycling?*

Note: Putting the "O" back in O&M

Consider how poor maintenance adversely affects operational performance. Likewise, poor operation practices can increase the amount of maintenance required to keep equipment running.

O&M Best Practices series (1999). *Putting the "O" Back in O&M*, US EPA/US DOE.

Definition: The Preventive Operations & Maintenance Plan

A Preventive Operations and Maintenance Plan contains the following information for each piece of equipment on the equipment list.

Operations information

- Parameters for normal operation
- Settings and setpoints for the control strategies
- Alarm limits for different operating modes

Maintenance information

- Expected equipment life
- Expected annual energy use
- Maintenance schedule
- Maintenance task descriptions
- Forms for collecting and documenting required information

- *Are time-clocks checked monthly to ensure proper operation?*
- *Have any changes in room furniture or equipment adversely affected thermostat functions?*
- *Are new tenants educated in the proper use and function of thermostats and lighting controls?*

In all, a preventive O&M plan differs from a typical PM plan in that it calls for periodically checking operational and control issues and investigating issues that affect efficiency. To facilitate this, a reference list of operational parameters and the building’s adjustable settings can be developed to help monitor and maintain the proper settings for the facility. Building operators can be tasked with developing the list, or as part of the retrocommissioning scope of work, the commissioning provider can assist with it.

It may seem like expanding the PM plan would significantly increase the workload of building staff. However, performing these tasks on a regular, proactive basis should actually save staff time in the long run as preventive operation activities help to reduce occupant comfort complaints and equipment malfunction. Staff who spend more time on preventive operations generally spend less time “fighting fires” and troubleshooting problems.

Note: Outsourced Preventive Maintenance

When building staff is not available or trained to perform maintenance tasks, owners may have a maintenance service contract in place with an equipment vendor, installing contractor, or a maintenance service contractor. Most companies providing service contracts focus on the maintenance or care of equipment and systems, and building owners and managers need to specifically request requirements that address operating issues in service contracts.

If included in their scope of work, the commissioning provider can review any existing service contracts and make recommendations on how to enhance the current level of service to address efficient operation.

Resources

More information on service contracts can be found in *Operation and Maintenance Service Contracts: Guidelines for Obtaining Best-Practice Contracts for Commercial Buildings*, one of seven volumes in the US EPA/US DOE funded O&M Best Practices series. All seven are available in the CCC library: www.cacx.org.

Performance Tracking

Performance tracking is a vital tool that helps building operators detect and diagnose problems early, before they lead to tenant comfort complaints, high energy costs and unexpected equipment failure.

Lighting and HVAC systems have become so complex that continuous performance tracking (using trend logs and utility bills) is key for building operators to know when systems aren't functioning properly. Unfortunately, a process for data gathering and analysis is not usually established.

There are three important strategies for performance tracking:

- Benchmarking
- Utility tracking
- Trend analysis

Each of these strategies is a common task in a retrocommissioning project and, therefore is an opportunity for the building staff to learn and perform activities and then continue to implement them. They are especially important in monitoring and maintaining the measures implemented as a result of the retrocommissioning process beyond the project's end.

Benchmarking

Benchmarking is a way for building owners and operators to track their building's energy use over time and compare it to other buildings. Owners of multiple buildings can use benchmarking to compare buildings and prioritize improvements.

Several online resources are available to help with building benchmarking. Two of the most comprehensive and widely applicable are ENERGY STAR Portfolio Manager and the Cal-Arch Building Energy Reference Tool.

ENERGY STAR Portfolio Manager

Portfolio Manger is the most widely used building benchmarking tool. It was developed by the U.S.

Note: Benchmarking Tools

ENERGY STAR Portfolio Manager
www.energystar.gov/benchmark

Cal-Arch Building Energy Reference Tool

Environmental Protection Agency (EPA) and since 1999 approximately 12% of the total building market has been benchmarked using this tool.

This web-based tool uses the energy bill data and building characteristics supplied by building staff to rank the building compared to other, similar buildings. When it compares buildings, Portfolio Manager takes into account factors that are outside the control of the building staff, like climate, occupancy level, hours of operation and space use. Buildings scoring 75% or higher can apply for the ENERGY STAR label.

Additionally, buildings seeking LEED-EB certification must be benchmarked using the ENERGY STAR Portfolio Manager tool and achieve a rating of at least 60%.

Cal-Arch Building Energy Reference Tool

This web-based tool shows how a building's energy use per square foot compares to other California buildings. Unlike Portfolio Manager, Cal-Arch doesn't take anything into account except the size of the building and the amount of energy it uses. As a result, Cal-Arch can be faster and easier to use, but may not be as helpful in detecting and explaining differences in performance. Energy-intensive buildings like labs or data centers may receive low rankings because they use a lot of energy, even though they use it very efficiently.

Utility Tracking

Utility tracking and troubleshooting are key elements in ensuring long-term building performance. Where benchmarking compares utility consumption against other buildings, utility tracking measures the building's energy use over time and helps staff understand the building's energy consumption patterns. By tracking performance over time, facility managers and building operators can proactively address problems before they cause occupant discomfort or premature equipment failure. There are a host of energy accounting software tools available.

Trend Analysis

Trending is important for observing the performance

<http://poet.lbl.gov/cal-arch/>

[Lawrence Berkeley National Laboratory Cleanroom Benchmarking](http://poet.lbl.gov/cal-arch/)

<http://ateam.lbl.gov/cleanroom/benchmarking/>

[Oak Ridge National Laboratory Benchmarking Spreadsheets for Office Buildings](http://eber.ed.ornl.gov/commercialproducts/cbenchmk.htm)

<http://eber.ed.ornl.gov/commercialproducts/cbenchmk.htm>

Note: Utility Tracking Strategies and Tools

Compare average daily consumption curves for different years, looking for significant variations not attributable to changing loads or weather.

Compare peaks and valleys of curves to identify energy efficiency opportunities.

Select the type of EIS that matches the building's needs – there are several, including:

- Utility-EIS: automates process of gathering utility data
- Demand Response: a feature that helps a building reduce energy use when total system loads are high
- Enterprise Energy Management: tracks utility data for several buildings, and compares them
- Web-based Energy Management and Control: allows for the monitoring of utility data over the internet

of the systems under various modes and operating conditions over time. It is also typically the central strategy for ensuring that the implemented retro-commissioning measures are persisting.

The data handling capabilities of DDC systems allow building staff to “listen” to the building by supplying data on building operations over time. In order to be useful, a DDC system must have enough memory and communications capacity to trend and archive data. It is also important to understand how the system stores data. Are they automatically downloaded to a hard drive, or does this process need to be scheduled?

Without analysis capabilities, however, the data will be unused. When building staff are not familiar with the trending capabilities of the DDC system, or unskilled in how to set up trends and retrieve collected data, it may be helpful to bring the control vendor onsite for training.

However, data collection is just the first step. Staff should also be trained on how to analyze and interpret the data. To assist the staff responsible for this, important metrics can be defined and evaluated, and illustrative diagnostic charts can be “canned” to allow collected data to be reviewed in the most informative format to diagnose particular problems.

If it is part of the retrocommissioning scope, the commissioning provider can set up “smart alarms” in the DDC system, or alarms that look at concurrent values of several variables at one time or compare variables to limits that depend on the operating mode. Operators should be trained on what the alarm conditions signify, how to respond to these alarms when they are triggered, and how to set up their own alarms.

Resources

Energy Information Systems can be used to harvest the data from a DDC system, and perform powerful analysis, diagnostics, and reporting. For more information, check out these publications, both available in the California Commissioning Collaborative’s on-line library (www.cacx.org/library):

Motegi, Piette, Kinney, and Dewey. “Case Studies of Energy Information Systems and Related Technology: Operational Practices, Costs, and Benefits” (2003). PIER.

Sakurai, Culp. “Guide to Using Energy Management Control Systems (EMCSs) for Monitoring” (2003). PIER.

Recommissioning Plan

Recommissioning occurs when a building that has already been commissioned undergoes another commissioning process to help keep it operating according to the owner's operating requirements. Ideally, a plan for recommissioning is established as a result of the retrocommissioning process.

The need for recommissioning depends on several things: changes in the facility's use, quality and schedule of preventive maintenance activities, and the frequency of operational problems. In California, recommissioning is required of all state buildings of more than 50,000 square feet on a recurring five-year cycle, or whenever major energy consuming systems or controls are replaced. Thus, to meet these requirements it is important that the recommissioning timeline be a part of the scope.

The recommissioning process is similar to retrocommissioning, although it is less expensive since some of the difficult data collection and documentation tasks will have already been completed and need only to be revalidated. The process typically begins with a review of the owner's operating requirements of the building to determine if there have been any changes. When changes have occurred, systems are reviewed to determine if corresponding changes in equipment or operations are necessary. Next, systems are inspected and any issues are recorded in a *Findings Log*.

Functional performance tests and trend logs may be used to determine if the systems are still operating as intended. Minor system improvements may be implemented during recommissioning, while others may require more significant design, scheduling and budgeting. The building documentation will also be reviewed to determine if updates or trainings are required. Finally, the *Owner's Operating Requirements* document is updated to reflect any changes in building systems and functions.

Note: Time to recommission?

Positive answers to two or more of the following questions indicates that it may be time to recommission:

- Is there an unjustified increase in energy use? Is energy use more than 10% higher than previous years?
- Have comfort complaints increased compared to previous months or years?
- Has nighttime energy use increased?
- Is building staff aware of problems but without the time or in-house expertise to fix them?
- Has control programming been modified or overridden to provide a quick fix to a problem?
- Are there frequent equipment or component failures?
- Have there been significant tenant improvement projects (build-outs)?
- For State of California buildings over 50,000 square feet: Has it been five years or more since the previous recommissioning process? Have any major energy consuming systems or controls been replaced recently?

Continuous and Monitoring-Based Commissioning

Rather than conducting discrete re-commissioning processes, it can be quite effective to institute a program of “continuous” or “monitoring-based” commissioning.

In Continuous CommissioningSM (practiced by the Energy Systems Laboratory of Texas A&M University), commissioning providers work closely with building staff to commission major pieces of equipment, and involve the building staff in selecting and implementing improvements. The providers then commission the entire building, optimizing it to current operating requirements. Monitoring equipment is left in place, and a dedicated analysis staff reviews data to ensure persistence of savings.

Monitoring-Based Commissioning (in a program provided by the University of California and California State University systems, along with California utilities) is similar in that it has an emphasis on involving the building staff and leaving monitoring equipment for ongoing diagnostics. It has an increased emphasis on training of the building staff, and empowering them to use the monitoring through analysis training, automation of diagnostics and “smart” alarms.

Both of these programs have a goal of making immediate improvements to the building, and to establish a baseline of appropriate operation. They utilize ongoing monitoring to detect deviations from that baseline, and to identify the need for continued operational improvements. Recommissioning may still be needed, but it should be required at less-frequent intervals, and should be much more tightly focused due to the availability of trained staff and monitored data.

6. Getting Started

So how does an owner or building manager get started with retrocommissioning? There are a few key steps that will help get a new retrocommissioning project off to a strong start:

Become informed about retrocommissioning

Explore the resources listed in this Guide, including online resources such as the California Commissioning Collaborative Web site (www.cacx.org). Also, talk to others about their experiences with retrocommissioning.

Determine if your building is a good candidate for retrocommissioning

While most buildings can benefit in some way from retrocommissioning, some buildings are better candidates than others. There are several indicators, discussed in Chapter 3 of this Guide, that may predict a project's chance of success and increase its cost-effectiveness.

Develop a long-range plan for commissioning your portfolio of buildings

For owners or managers of multiple properties, a multi-year, organization-wide strategy may be useful when implementing retrocommissioning. Developing a strategy helps to prioritize projects and develop a plan that will address as many buildings as possible. An owner may choose to select the most cost-effective projects first, providing funding and justification for implementing the less cost-effective projects in subsequent funding-cycles. Or owners may “bundle” multiple buildings into one project—including both highly cost-effective and less cost-effective buildings into one reasonably cost-effective package. This will ensure that retrocommissioning can occur in as many buildings as possible while meeting the organization's overall cost-effectiveness requirements.

Determine what local, utility and government resources are available

More and more frequently, utilities are offering programs for existing buildings that target O&M measures. Contact utility representatives and government agencies to learn about the incentives they offer for existing building commissioning and other energy efficiency products and services.

Determine what budget is available

Understanding how your organization allocates funds for maintenance expenditures and capital improvements may reveal sources of funding for retrocommissioning that would have gone unused or been spent on other projects.

Obtain buy-in from members of the organization

Consider giving a presentation on retrocommissioning or inviting a commissioning provider to come explain its benefits to staff. Identify any decision-makers in your organization who may need convincing and be sure they are aware of the many financial

benefits from retrocommissioning, including reduced utility bills, risk management, quick returns on investment, and increased asset value.

Hire a commissioning provider

The size and complexity of the project and the availability and skill set of the in-house staff will determine the extent of services that are needed from a commissioning consultant. To select a commissioning provider that is right for your project, identify commissioning providers working in the area and begin investigating their qualifications. Ask whether the provider's experience is relevant to your project's needs. Once a provider is selected, the owner and provider work together to clearly scope the process and define the objectives.

Build the in-house team

Designate at least one in-house staff person to be a part of the retrocommissioning team. The ideal staff members to participate are those familiar with the building history and who understand how – and why – the systems are operated. The team should include a “champion” who is enthusiastic about the potential benefits of the process, as well as a highly-placed stakeholder who can communicate the organization's strong commitment to the retrocommissioning process. With this team in place, the project has the best chance to achieve its energy and cost-savings potential.