A RETROCOMMISSIONING GUIDE FOR BUILDING OWNERS

Developed by PECI with funding from
the US EPA ENERGY STAR® Program

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
AIR AND RADIATION

I am pleased to introduce *A Retrocommissioning Guide for Building Owners*, developed with assistance from the U.S. Environmental Protection Agency under a cooperative agreement with Portland Energy Conservation, Inc.

Retrocommissioning is a process that helps to ensure that building equipment and systems perform together effectively and efficiently to meet your operating requirements and expectations. It is an important tool to improve the energy performance and occupant comfort of your commercial building. This guide is designed to help you understand the benefits of the retrocommissioning process and ensure the quality of the services you receive.

Now more than ever, it is important to find and eliminate energy waste in buildings. The energy used by commercial and industrial buildings in the United States is responsible for 45 percent of the nation's greenhouse gas emissions. EPA encourages all building owners to take part in the ENERGY STAR Challenge, a national call to action to improve the energy efficiency of America's buildings by 10 percent or more. We estimate that a 10 percent improvement would save about $20 billion and reduce greenhouse gases equal to the emissions from 30 million vehicles.

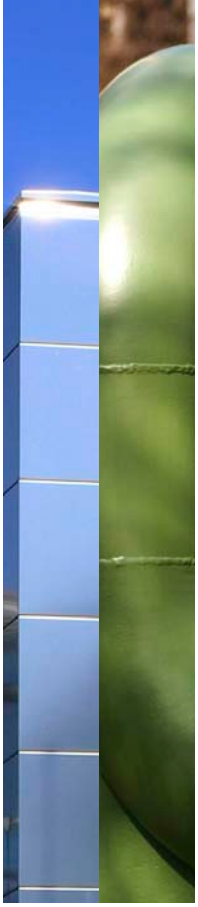
Through the ENERGY STAR Program, EPA has found that the most successful organizations start by managing energy as a strategic part of their business. EPA provides tools and resources used widely in the commercial buildings market to help organizations establish a strategic energy program, assess the current energy performance of buildings, set organizational goals, track savings, and reward improvements.

You can do your part to help reach this goal. Start by using the EPA energy performance rating system to assess the current energy performance of your buildings, and then use this retrocommissioning guide as a first step to identify cost-effective savings. You may be surprised to find that it is easier than you might think to improve the energy performance of your buildings by 10 percent or more.

Sincerely,

Jean Lupinacci

Jean Lupinacci, Director
ENERGY STAR Commercial and Industrial Branch
U.S. Environmental Protection Agency

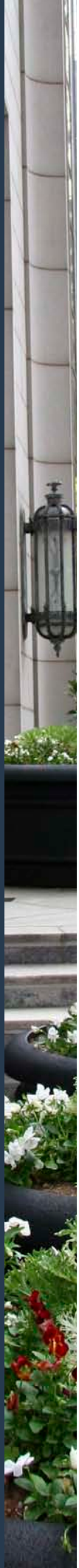


A RETROCOMMISSIONING GUIDE FOR BUILDING OWNERS

2007

Developed by Portland Energy Conservation, Inc.
with funding from the U.S. Environmental Protection Agency
ENERGY STAR® Program

A Retrocommissioning Guide for Building Owners was developed by Portland Energy Conservation, Inc. (PECI) under Assistance Agreement No. XA 831954-01, awarded by the US Environmental Protection Agency (EPA). It has not been formally reviewed by EPA. EPA does not endorse any products or commercial services mentioned in this publication. EPA and PECI make no warranty, express or implied, and assume no legal liability for the information in this guide.



ACKNOWLEDGEMENTS

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

Glen Anderson, Principal, ETC Group

Matthew W. Berbee, Energy Manager, NASA Jet Propulsion Laboratory

Lee Burns, Director of Engineering, Bentall Capital US Inc.

Mark E. Case, President, ETC Group

Byron Courts, Director of Engineering Services, Melvin Mark Company

Fouad Dagher, Coordinator, National Grid

George Denise, General Manager, Client Solutions Group, Cushman & Wakefield of California, Inc.

Michael Dineen, Building Engineer, Cushman & Wakefield of California, Inc.

Michael Hatten, Principal Engineer, Solarc Architecture & Engineering, Inc.

George Leitch, Control Systems Specialist, Facilities Management Division, Washington Group International

Ted Ludwick, Assistant Chief Engineer and Sustainability Manager, Cushman & Wakefield of California, Inc.

Brendon Mattis, Senior Engineer, EEI Engineers

Joe Ohama, Facilities & General Services Manager, Real Estate & Facilities Department, Tektronix, Inc.

Greg Schlegel, Senior Analyst, ETC Group

Jerry Siemens, Senior Mechanical Engineer, Washington Group International

ABOUT THIS GUIDE

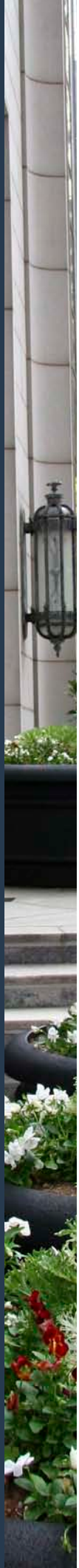
A Retrocommissioning Guide for Building Owners (the Guide) illustrates how building owners and managers can successfully use retrocommissioning as a cost-effective method to reduce expenses and increase revenue through improved building operations. The more an owner is involved in the retrocommissioning process, the lower the costs, the larger the benefits, and the longer the impact. This guide was created to address the opportunities that owners have to significantly increase the benefits of retrocommissioning in their buildings.

Building owners can use this document as a guide to better understand the impact of the retrocommissioning process and communicate internally to others about issues, benefits, and need for staff involvement. As the retrocommissioning team moves through each phase of the process, the individual charged with leading the effort on the owner's side (referred to as the owner's representative or, simply, "owner" throughout the remainder of this document) can use this guide as a reference to gain a better understanding of each phase and to lead the team in taking the appropriate steps to ensure success.

A Retrocommissioning Guide for Building Owners is designed to guide the owner in achieving the following components of a successful and cost-effective retrocommissioning project:

- ✓ Facility staff are able to complete a portion of the work – reducing the budget required to pay the commissioning provider or subcontractor.
- ✓ Building staff learn about enhancing the operation of their building as they work alongside the commissioning professional– improving their ability to maintain the performance of systems after the project is complete.
- ✓ Budgeting for retrocommissioning flows smoothly because the owner understands the associated benefits.
- ✓ Short and long-term plans for implementing improvements are created; retrocommissioning opportunities are assessed for risk management and the potential to generate revenue; and the costs are integrated with budget planning.
- ✓ Benefits are long lasting through the implementation of persistence strategies.

The first two sections of this guide, "Building Performance as a Business Strategy" and "Investing in Retrocommissioning," are written with the financial decision maker in mind. In some cases, that may be a corporate CFO or a regional energy



manager. In other situations, it may be a private building owner or owner's representative. It is critical that the person in control of allocating operational budgets understands the financial rationale and economic opportunity of retrocommissioning.

The section entitled "Project Basics" includes a quick summary of the retrocommissioning process, an explanation of the roles and responsibilities of the team, and a final checklist of "Key Strategies for Success." The "Key Strategies for Success" checklist acts as a portal into the rest of the document and provides quick links to critical information as the reader embarks on and moves through a retrocommissioning project.

The remainder of the Guide expands on the process steps summarized in the "Project Basics" section and is divided into six parts:

Project Planning – Part 1
Project Planning – Part 2
Investigation
Implementation
Project Hand-Off
Making Retrocommissioning Benefits Last

At the end of the Guide, the Resources section (see p. 87) provides links to additional tools and information that owners may find helpful in understanding and managing the retrocommissioning process.

Development of this *Retrocommissioning Guide for Building Owners* supports the U.S. EPA ENERGY STAR® program goal to offer businesses and consumers energy efficient solutions that save money and protect the environment. The Guide is intended to increase clarity and consistency of market standards for both commissioning providers and building owners. It also presents a clear strategy for ENERGY STAR® partners to improve their performance rating and adopt a long-term energy management strategy by retrocommissioning appropriate buildings in their portfolio.

A Retrocommissioning Guide for Building Owners builds on existing resources used around the country and addresses new concepts and practices in the industry. It provides links to a comprehensive range of sample documents for commissioning customers and practitioners. The Guide helps the U.S. EPA provide building owners and commissioning providers with the necessary tools to improve whole building performance through persistent, cost-effective building operations that are in line with building owners' budgets and practical needs.

TABLE OF CONTENTS

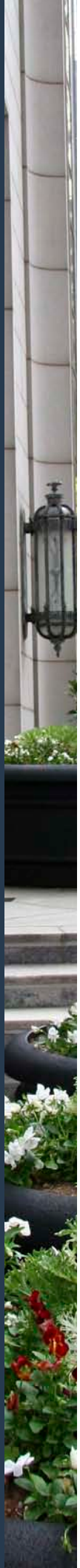
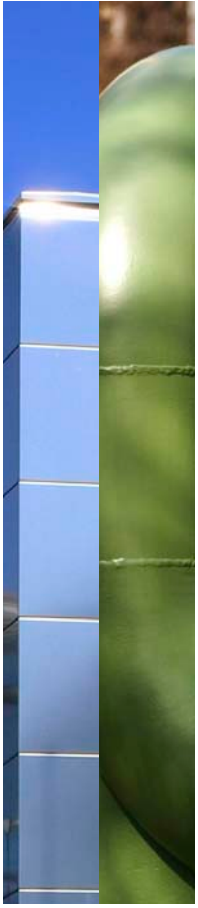


TABLE OF CONTENTS (continued)



1. BUILDING PERFORMANCE AS A BUSINESS STRATEGY

How well a building performs not only affects utility bills – it also can influence property value, the productivity of occupants, and the business bottom line. Although high energy use is sometimes accepted as an unavoidable cost of doing business, it may be an indicator of opportunities for reducing inefficiency and waste linked to building performance issues and gaps in how operation and maintenance (O&M) activities are carried out. By actively pursuing building operating improvements, building owners and managers can significantly reduce operating costs to increase the profitability of their business and gain a competitive edge in the marketplace.

This section describes the potential for broad gains from activities aimed at improving building performance and introduces the concept of retrocommissioning (RCx) and its benefits.

Highlights:

- How retrocommissioning improves building profitability and reduces risk
- The differences between commissioning, retrocommissioning, recommissioning, and ongoing commissioning
- Goals of retrocommissioning

Chapter 1

A CASE FOR IMPROVING BUILDING PERFORMANCE

No matter how well building operators and service contractors maintain equipment, if it operates inefficiently or more often than needed, energy waste and reliability problems can occur. Also, over time, building uses change – occupants move, spaces are reconfigured, new equipment is added – rendering previous systems and settings ineffective.

Today's buildings are complex, employing highly inter-dependent systems with sophisticated controls; therefore, even small operational problems can have big impacts on performance. Even if building staff have been able to work out most of the operational "bugs," they are often forced to solve daily problems under severe time constraints and without the benefit of appropriate or complete documentation or training on system-integration issues.

Commissioning and Retrocommissioning Defined

Commissioning is an intensive quality assurance process that begins during the design of a new building and continues through construction, occupancy, and operation. Commissioning ensures that the new building operates as the owner initially intended and that building staff are prepared to operate and maintain its systems and equipment.

Retrocommissioning applies the commissioning process to existing buildings and seeks to improve how building equipment and systems function together. Retrocommissioning can often resolve problems that occurred during building design or construction, or address problems that have developed during the building's life.

RETROCOMMISSIONING CAN HELP

Achieving optimum building performance requires an approach that helps to ensure that equipment and systems perform together effectively and efficiently to meet the building owner's operating requirements and expectations. When this process occurs during the construction of the building, it is referred to as "commissioning." Applying a similar process to existing buildings and their operations is referred to as "retrocommissioning."

Retrocommissioning is a collaborative process that looks at how and *why* a building's systems are operated and maintained as they are, and then identifies ways to improve overall building performance. As a process, rather than a set of prescriptive measures, retrocommissioning adapts to meet the specific needs of each owner. Since occupant comfort complaints and high energy use can often go hand-in-hand, retrocommissioning can help to correct both. Specifically, retrocommissioning:

- Improves the building's overall performance by optimizing energy efficient design features and directly addressing equipment performance and system integration issues.

- Ensures that building staff have the knowledge and documentation needed to operate and maintain the building.

- Evaluates the building's environmental quality to reduce occupant complaints by optimizing existing systems.

Optimum building performance can be maintained over time following retrocommissioning through persistence strategies such as *recommissioning* or *ongoing commissioning*.

- *Recommissioning* involves applying the commissioning process to a building that has been previously commissioned (during new construction) or retrocommissioned. It is normally done every three to five years, or whenever the building experiences a change in use.

- In *ongoing commissioning*, monitoring equipment and trending software is left in place to allow for continuous tracking, and the scheduled maintenance activities are enhanced to include operational procedures. For ongoing commissioning to be highly effective, the building owner must retain high quality staff or service contractors that are trained and have the time and budget to not only gather and analyze data, but also to implement the solutions that come out of the analysis.

Case Study: Target Retrocommissioning Program

Thanks to retrocommissioning at several SuperTarget® stores, Target identified adjustments to its refrigeration systems which resulted in a $5,000 - $10,000 annual energy savings per store. Due to the potential risks associated with food quality if refrigeration systems do not perform, Target funded this effort not only as an energy savings measure, but also as a risk minimization strategy.

Source: Williams, Scott D. PE, "Owner's Strategies for In-house Commissioning," *Proceedings of the National Conference on Building Commissioning* (New York, NY, May 4 - 6, 2005).

Chapter 1

RETROCOMMISSIONING AS PART OF YOUR BUSINESS STRATEGY

Retrocommissioning can benefit a building owner in a number of ways:

- **Reduce utility costs.** Through retrocommissioning, whole-building energy use may be reduced by an average of five to 15 percent. In some cases, annual savings of as much as 30 percent are possible.[1]

- **Protect or enhance property value.** Reducing operating costs helps to maintain high occupancy rates, reduces tenant turnover, and enables an owner to gain a competitive edge in the marketplace.

- **Protect against future liability.** A building's indoor environmental quality affects the health, comfort, and productivity of its occupants and ranges from mildly inconvenient to very serious. Retrocommissioning can help identify and address problems that can lead to future liability.

- **Reduce repair and replacement cost.** Retrocommissioning improves system performance, increases equipment life, and reduces the need for repairs, which can save money and result in fewer comfort complaints.

- **Increase a building's EPA energy performance rating**. More and more tenants are becoming concerned about environmental issues and how their work place measures up. The EPA acknowledges the commitment and achievement of organizations that have adopted energy performance goals into their core business strategies (see next page).

Putting the "O" in O&M

Preventive and predictive maintenance programs, out of necessity, focus on component by component care and seldom include comprehensive investigation of how systems operate together. Retrocommissioning goes beyond the scheduled maintenance of a building to address the "O" in O&M by providing a thorough assessment of the operation of mechanical equipment, lighting, and related controls to improve how the building operates as an integrated system. Retrocommissioning enhances a preventive maintenance program by including methods for ensuring that operating improvements remain functioning as intended. For buildings that do not have an active preventive maintenance program, retrocommissioning can be a key element in re-establishing control over the building's maintenance processes and procedures.

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

Differentiate Your Building with an ENERGY STAR® Label

More and more building owners are strategically pursuing the business opportunities of energy efficiency. In response to this interest, initiatives such as the U.S. Environmental Protection Agency (EPA) ENERGY STAR program have emerged. For businesses and organizations, ENERGY STAR is built around the principle that effective energy management is good for business as well as the environment. Over 7,000 organizations are ENERGY STAR partners, working with EPA to improve whole building energy performance.

Retrocommissioning plays an important role in addressing whole building performance by looking at buildings as integrated systems, rather than a set of individual components. Buildings earn the ENERGY STAR label by demonstrating that the energy use of their whole building performs in the top 25th percentile compared to similar buildings. The EPA energy performance rating system is used to assess energy using a standard metric, which can be used to identify the lowest performing buildings in a portfolio and to demonstrate success after a retrocommissioning project. As an easily applied benchmark, it also can be used to determine when performance is slipping and recommissioning may need to occur. More information on ENERGY STAR for buildings can be found on the EPA website at **www.energystar.gov/labeledbuildings**.

At the end of 2006, more than 3,200 buildings had earned an ENERGY STAR label. These buildings represent more than 575 million square feet, save an estimated $600 million annually in lower energy bills, and prevent almost 11 billion pounds of greenhouse gas emissions, equal to emissions from almost 900,000 vehicles.

Recognition Opportunities

EPA acknowledges the commitment and achievement of organizations that have adopted energy performance goals into their core business strategies. Partner companies are recognized as "ENERGY STAR Leaders" when they achieve significant improvements across their building portfolio compared to their organization's baseline. Organizations can leverage this national recognition in the market as a symbol of environmental stewardship and superior energy management. For details on eligibility, visit the ENERGY STAR website at **http://www.energystar.gov/leaders**.

Retrocommissioning and Green Building Certification

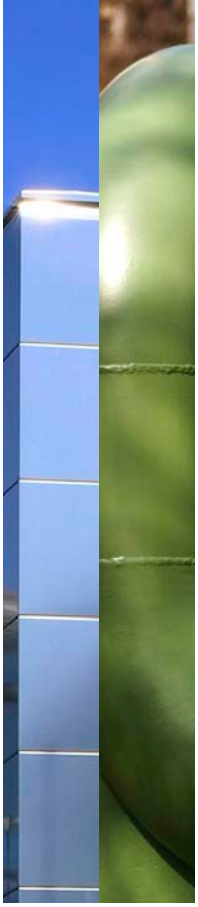
Retrocommissioning and the EPA energy performance rating are both a part of the Leadership in Energy and Environmental Design (LEED®) for Existing Buildings Rating System™, which goes beyond energy performance to include additional sustainability measures.

What is LEED?

LEED is a series of green building rating systems developed by the U.S. Green Building Council (USGBC). These systems are designed to help an owner achieve an accepted "green building" standard for new construction and retrofit projects. There are distinct rating systems for new construction (LEED-NC™), existing buildings (LEED-EB™), and several other situations. 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.

Using Retrocommissioning to Meet LEED-EB Requirements

Existing buildings seeking LEED-EB certification can receive points based on the building's EPA energy performance rating. Implementing a retrocommissioning process will help achieve the minimum performance rating required by LEED. Retrocommissioning measures can help buildings earn points toward certification under LEED-EB. More information about the LEED Rating Systems can be found on the U.S. Green Building Council's website at **www.usgbc.org**.



2. INVESTING IN RETROCOMMISSIONING

How does a business make the decision to invest in retrocommissioning? Simple payback for a retrocommissioning project is typically less than two years and often less than one year. In addition, the process secures better and longer performance out of existing equipment, and the benefits reach far beyond energy savings. If this is true, why aren't all building owners adopting this strategy?

The answer may be in the perception of this type of investment. Each type of business has its own pressures that affect investment choices: healthcare is subject to constant regulation, real estate investment trusts (REITs) need to improve the value of their holdings and effectively manage leasable space, and service businesses are focused on sales and customer service. In these environments, putting money into a building to increase operating efficiencies may not be a high priority. This chapter describes the benefits and costs of a retrocommissioning project and concludes with guidelines for developing a business case for retrocommissioning that wins senior management support and approval.

Highlights:

- Reducing a building's energy use through retrocommissioning
- How building performance affects the bottom line and overall asset value
- Understanding the costs of retrocommissioning
- Strategies for reducing retrocommissioning costs
- Keys to building the business case for your retrocommissioning project

Chapter 2

DIRECT SAVINGS POTENTIAL

A prevailing myth is that the many expenses associated with operating and maintaining a building are an unavoidable cost of doing business. The reality, however, is that the majority of buildings can operate at equivalent or improved levels of comfort and function for less money. Retrocommissioning addresses this inefficiency by reducing operating costs through low-cost investments with high rates of return.

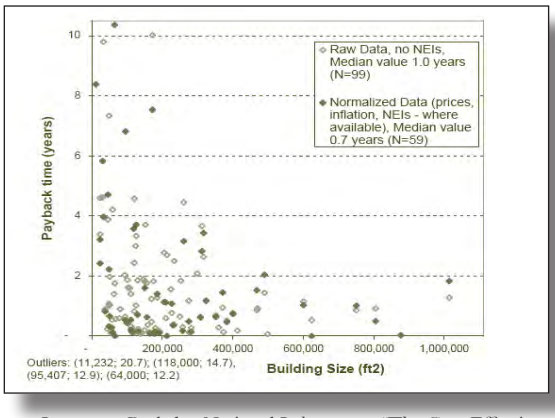
Savings from Retrocommissioning

Cost savings from retrocommissioning can be significant; however, they can also vary significantly depending on building type and location, and the scope of the retrocommissioning process. A comprehensive study found average cost savings in the following ranges:

Value of Energy Savings	$0.11 - $0.72/ft²
Value of Non-Energy Savings	$0.10 - $0.45/ft²

Significant cost savings from a retrocommissioning process are often a result of reduced energy use. A 2004 study conducted by Lawrence Berkeley National Laboratory (LBNL) aggregated retrocommissioning results from 100 buildings[2] and found whole-building electricity savings ranging from five to 15 percent and gas savings ranging from one to 23 percent. Corresponding payback times ranged from 0.2 to 2.1 years. The median project energy savings found through this study were approximately $45,000 per building (in 2003 dollars), and ranged as high as $1.8 million. Payback times typically decline with increasing building size, especially for buildings with floor area above 100,000 square feet (see Figure 1 below).

Figure 1. Commissioning Payback Time vs. Building Size (Existing Buildings)



Source: Lawrence Berkeley National Laboratory, "The Cost Effectiveness of Commercial-Buildings Commissioning," December 2004.

2 The data in this section is based on information provided in the following publication: Mills, E., H. Friedman, T. Powell, N. Bourassa, D. Claridge, T. Haasl, and M.A. Piette. 2004. "The Cost-Effectiveness of Commercial-Buildings Commissioning," Lawrence Berkeley National Laboratory. http: //eetd.lbl.gov/EMills/PUBS/Cx-Costs-Benefits.html

There are certain economies of scale associated with retrocommissioning. For example, base costs are linked to the number of systems in a building. Consequently, for a large and small building with the same number of systems, per square foot costs of retrocommissioning will be lower for the larger building. Although it can be more challenging, smaller building owners can still achieve cost-effective commissioning with payback times under two years. Also, payback periods typically decline with increases in facility energy costs. For example, the LBNL study found that laboratories, which have the highest energy cost per square foot, had the shortest payback periods. In contrast, schools, with relatively low energy costs per square foot, had longer payback periods. The article, **Meticulous Study Makes the Case for Cost-Effective Commercial-Building Commissioning** summarizes the LBNL study (to access this article, visit **www.betterbricks.com**).

Case Study: Marriott Marquis

Marriott's flagship property, the Marriott Marquis, a 50-story structure located in Times Square in New York City includes nine floors of retail and meeting rooms, 35 floors of occupant rooms, five restaurants, and a 1,500 person theater. In order to achieve the goal of reducing operational energy consumption, Marriott used a retrocommissioning process to determine if improved operation could result in energy savings. In contrast to the efficiency measures the hotel had implemented in the past to maximize lighting and guest room controls, significant opportunities were found in areas separate from the guest facilities, allowing the hotel to improve its bottom line without altering its functionality to its guests. Among other improvements, by optimizing the facility's chilled water plant and installing variable speed drives on the air handling system, the facility was estimated to save $775,000 per year. Through this project, Marriott was able to improve on the building's mechanical systems, maximize efficiency, and shield against ever-rising energy costs all with simple payback of less than two years.

Source: NYSERDA case study drafted by Portland Energy Conservation, Inc.

Recovering Investments in Income-Producing Properties

In many buildings the return on investment is easy to see. Owners who pay all of their energy costs will directly benefit from reduced energy use. In income-producing properties, however, the payback to the owner may be harder to see and is complicated by the variety of leasing arrangements used in commercial real estate. Even within one owner's portfolio of buildings it is not unusual to have a different lease agreement with each tenant. In reality, however, owners can realize a return on energy efficiency investments under most lease arrangements.[3]

3 Information in this section is summarized in part from the following publication: Jewell, Mark. RealWinWin, Inc. "Understanding the Value of Commissioning in Income-Producing Office Buildings," *Proceedings of the National Conference on Building Commissioning* (Palm Springs, CA, May 20 – 22, 2003).

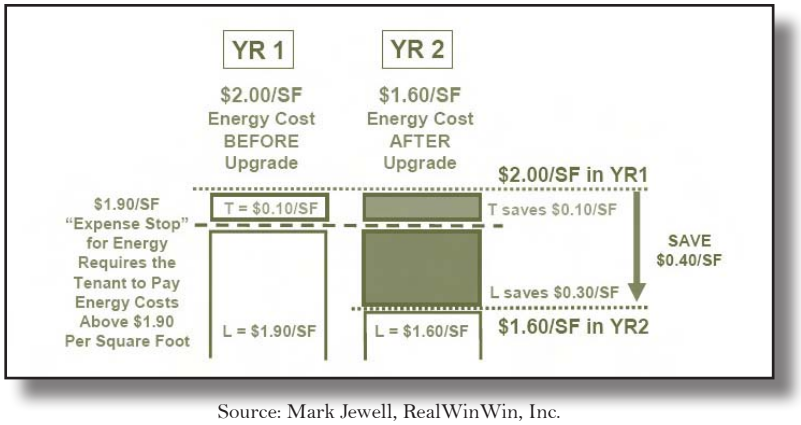
The value of proposed energy efficiency improvements to an owner can be determined by evaluating how different leasing arrangements divide energy costs and savings between the owner and tenant. While leases typically prohibit the building owner from passing the cost of most capital expenditures to tenants, some leases allow the owner to assess tenants for capital projects that reduce operating expenses. It is important to understand how a building's leasing structure affects owner savings in order to adequately evaluate the potential benefits of retrocommissioning.

Three types of basic tenant lease agreements are typically used in income properties: gross leases, net leases, and fixed-base (modified gross) leases.

- **Gross Lease.** Owner pays all utilities and, therefore, directly benefits from any reductions in utility costs. All improvements in building performance, therefore, increase the owner's *net operating income* (NOI).

- **Net Lease.** Tenant pays all utility costs, which can represent 30% of the average building's operating expenses, and receives a direct benefit from reduced operating expenses. Expenses associated with the building's common areas (shared hallways and lobby) are still the responsibility of the building owner; the owner will therefore directly benefit from reduced operating expenses for these common areas. Owners can include language in new leases (or in negotiated lease amendments) that transfers energy saving benefits to the owner, provided the owner invested the capital to produce those savings. Under net leases, how electricity use is metered, along with the specifics of lease terms, will determine the extent to which costs can be passed on to the tenant. Where electricity use is monitored by the owner using a submeter (rather than a direct utility meter), electricity expenses may be considered part of the tenant's business operating expenses, but not part of "Operating Expenses," as legally defined in the lease. While this distinction may seem trivial, in such cases an owner may not be able to exercise a common lease clause allowing recovery of capital project costs that reduce "Operating Expenses."

Figure 2. Allocating Savings in a Fixed-Base Lease



Source: Mark Jewell, RealWinWin, Inc.

- **Fixed-Base Lease.** Owner pays utilities up to a specified amount, called the "expense stop." Because the tenants are responsible for any expenses above the expense stop, it is the tenant who will experience the cost savings that result from energy efficiency measures. In such cases, tenants may be willing to contribute some capital to the project to gain long-term savings and other benefits of retrocommissioning. If utility expenses dip below the expense stop, the owner will benefit by a decrease in energy costs. If current year operating expenses are not significantly higher than the "base year" or "expense stop," the owner could capture virtually all of the energy cost savings.

Figure 2 illustrates how energy savings might be allocated between a tenant (T) and the owner/landlord (L) in a fixed-base lease. In this lease structure, the owner pays operating expenses up to the "expense stop" at $1.90 per square foot; any expenses over that amount are paid by the tenant. Here, retrocommissioning reduces annual energy cost from $2.00/ft^2 to $1.60/ft^2, with an associated reduction in annual operating expenses of $0.40/ft^2. Because of the "expense stop," the tenant receives $0.10/ft^2 in energy savings, while the owner realizes $0.30/ft^2 in energy savings.

Lease Structure and Operating Expenses

In situations where the owner is responsible for some or all of a property's operating expenses, successful retrocommissioning could generate real savings for that owner. This is most obvious in the case of a gross lease, where the owner pays all operating expenses. However, even in situations where the owner agrees to absorb the cost of operating expenses only up to a certain "expense stop" or "base year" level, the owner would benefit if operating expenses fell below that level. And in situations where the tenant's share of operating expenses escalates according to a formula that is not tied to actual operating expenses (e.g., an agreed-upon annual percentage increase), the landlord would directly benefit from any operating expense savings because he would not be required to pass those savings along to his tenant.

It is important to remember that operating expenses include more than just energy costs. Housekeeping, security, roads and grounds, repairs and maintenance, and administrative expenses are often included as well. Cost increases in other operating expense categories could offset reductions in energy expense. In the case of a gross lease, the landlord would still benefit because operating expenses would have been even higher without these energy-saving measures. With a fixed-base lease, however, reducing operating expenses to a level that is *below* the base year (which would generate real savings for the landlord) could be outweighed by an increase in another expense category. Moreover, once the tenant has begun to pay escalations (i.e., that portion of expense that is above the "expense stop" or "base year" level), it is the tenant that captures any savings that occur above the base level, while the landlord would capture any savings that occur below.

Increasing Asset Value of Income-Producing Properties

Improvements that reduce energy costs also can increase a property's asset value, even in cases where property turnover is fairly quick. While the value of energy efficiency investments may not be obvious for a company that regularly buys and sells properties, savvy real estate investors understand that increasing their *net operating income* (NOI) through retrocommissioning is a cost-effective way to raise asset value. Operating expense savings captured by the owner will drive their NOI higher, which in turn supports a higher appraised value of the building. Keep in mind that appraisal value is not only important when a building is sold; a high appraisal value is also critical for owners wishing to leverage the property's accumulated equity. Owners who choose to refinance their properties during the holding period can benefit from the larger amount of capital that can be withdrawn with a higher asset value.[4]

While there are several ways to appraise property value, the *Income Approach* is the most common method used to value income-producing buildings. This approach calculates building value by dividing the property's NOI by the current market capitalization rate (the market capitalization rate is determined by evaluating financial data for similar properties that have recently sold in a specific market):

$$\text{Asset Value} = \frac{\text{Net Operating Income}}{\text{Capitalization Rate}}$$

Retrocommissioning can improve NOI through stabilized or increased revenues that result from improved tenant comfort. Specifically, NOI for a given property will increase if:

- Improved tenant comfort allows the building owner to raise rents (or stabilizes rents during a down cycle in the leasing market) by making the building a more desirable place to live or work.

- As a consequence of improved tenant comfort, occupancy improves (or is maintained in a very competitive leasing environment). Also, owners will likely experience lower tenant turnover when tenants are comfortable and less apt to move.

Both higher rental rates and higher occupancy levels increase rental revenues. Add to this the operating cost savings realized from optimizing the building's energy-using systems and the result is a higher NOI that easily translates into higher asset value (assuming a stable capitalization rate).

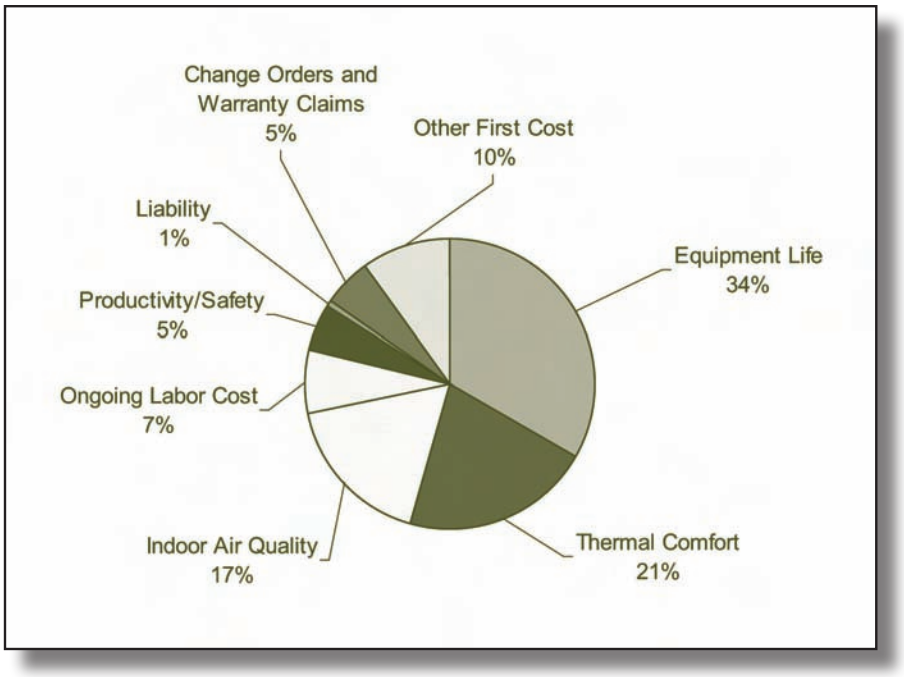
4 Information in this section is summarized in part from the following publication: Jewell, Mark. RealWinWin, Inc. "Understanding the Value of Commissioning in Income-Producing Office Buildings," *Proceedings of the National Conference on Building Commissioning* (Palm Springs, CA, May 20 – 22, 2003).

INDIRECT BENEFITS

The benefits of retrocommissioning go beyond reduced energy costs. While more difficult to quantify, these benefits should not be overlooked. Retrocommissioning can reduce maintenance costs, extend the life of building equipment, improve employee productivity, and improve indoor air quality. Even though these benefits may not yield direct monetary paybacks, they can generate associated cost savings. The dollar value of non-energy benefits alone can offset the cost of a project by 50 percent.[5]

In an analysis of commissioning project results, more than half of building owners reported benefits that went beyond energy savings. Extended equipment life and improved indoor thermal comfort were the most prevalent. Other retrocommissioning benefits (in order of decreasing incidence) included improved indoor air quality, first-cost reductions, labor savings, improved productivity/safety, fewer change orders and warranty claims, and liability reduction. Figure 3 below displays the percentage breakdown of these impacts. Where the economic value of these non-energy impacts was quantified, the value of the savings ranged from \$0.10 to \$0.45/ft² with a median value of \$0.18/ft² (\$17,000 of savings per project).

Figure 3. Reported Non-Energy Impacts (Existing Buildings)



36 Projects (81 benefits) Source: Lawrence Berkeley National Laboratory, "The Cost Effectiveness of Commercial-Buildings Commissioning," December 2004

5 The data in this section is based on information provided in the following publication: Mills, E., H. Friedman, T. Powell, N. Bourassa, D. Claridge, T. Haasl, and M.A. Piette. 2004. "The Cost-Effectiveness of Commercial-Buildings Commissioning," Lawrence Berkeley National Laboratory. http: //eetd.lbl.gov/EMills/PUBS/Cx-Costs-Benefits.html

Case Study: Symphony Towers

The Chief Portfolio Engineer of the Irvine Company, Inc., a 140-year old commercial real estate firm, decided to launch a retrocommissioning project, recognizing the importance of optimizing building performance as well as the value of the whole building engineering analysis offered by retrocommissioning. Of the more than 400 commercial office spaces in its portfolio, the company identified a building in downtown San Diego that qualified for a local utility incentive as its first candidate. Built in 1980, Symphony Towers is 714,000 square feet and has 34 stories.

The retrocommissioning project identified potential annual cost savings of $65,000. The high savings opportunities identified, coupled with relatively low implementation costs and program incentives, resulted in a payback of only four months for the project. Even without the utility incentives the payback would be a reasonable 14 months.

Investigation and Implementation

Through an in-depth operational analysis and close collaboration with building staff, the retrocommissioning provider identified several significant savings opportunities, including:

- Correcting uneven flow through the cooling tower
- Improving chiller sequencing
- Adjusting chilled water temperatures and setpoints
- Reducing cooling system night operation during the summer
- Optimizing the control of air-handling units (AHUs)

In all, seven energy-saving measures were selected and implemented in less than four months.

Project Costs and Savings

- Estimated annual kWh savings: 497,000 kWh
- Estimated annual cost savings: $65,000
- Total project cost: $76,600, including investigation and implementation
- Total program incentive: $52,800
- Net owner cost: $23,800
- Simple payback: 4 months
- Simple payback without incentive: 14 months

Non Energy Benefits

- Improved cooling tower operation and reduced maintenance costs
- Increased chiller efficiency and reduce chance of premature failure
- Quality documentation and training for building engineers
- Performance tracking of implemented measures and feedback to building engineers
- Improved tenant comfort

Source: The Irvine Company and the San Diego Gas & Electric (SDG&E®) Retrocommissioning Program

Case Studies: Office Buildings

Crown Plaza is a 311,000 square foot office building built in 1979 and located in Portland, Oregon. In 2005, the building's owner applied to participate in the local retrocommissioning incentive program, which included a full retrocommissioning investigation of the property, as well as incentives to support implementation of measures. The retrocommissioning investigation identified many hidden problems and opportunities for improvement. The implemented measures included optimizing the supply fan duct static pressure set points, reducing reheat and increasing the number of hours the building is in economizer mode, trimming impellers on oversized chilled water pumps, and shutting terminal units in unoccupied floors during weekend occupancy. In addition, lighting in the parking garage, which had been used 24 hours a day, seven days a week, is now scheduled. The building owner implemented a total of 19 identified measures, reducing annual energy expenses by an estimated $53,967.

Project Cost (including incentives): $47,100
Estimated Annual Cost Savings: $53,967
Estimate Annual kWh Savings: 775,339 kWh
Simple Payback: 0.87 years
Non-Energy Benefits: Increased equipment life, including chillers and pumps; reduced replacement costs for lighting in the parking garage; improved control of equipment such as air handlers, air terminal units, and chillers.

Source: Byron Courts, Director of Engineering Services, Melvin Mark Company, August 2007.

The Ronald V. Dellums Federal Building is a 1.2 million sq. ft. office building built in 1994. In 2001, the building's owner (U.S. General Services Administration) hired a commissioning provider to install new software for the building's control system as a way to improve energy performance. In the initial assessment, the provider discovered that air handlers were operating inefficiently and poor programming required building operators to run the central chiller plant manually. The provider recommended that the owner retrocommission the building to effectively reduce the building's energy use. Retrocommissioning identified several low-cost and relatively simple operations improvement opportunities with dramatic savings potential. The implemented measures, which included relocating sensors, optimizing the static pressure setpoint, and repairing the economizer dampers, saved the owner $66,981 in annual utility expenses – providing a payback period of less than one year.

Project Cost: $35,000
Size: 1.2 million sq. ft.
Energy Benefits: $66,981 in annual utility expense savings
Non-energy Benefits: Reduced staff time to manually operate systems, more efficient operations, increased controls stability, extended equipment life, bet¬ter facility staff understanding of systems operation and diagnostics set-up.

Source: California Commissioning Collaborative, http://www.cacx.org/resources/commissioning.php

Chapter 2

COSTS OF RETROCOMMISSIONING AND STRATEGIES TO REDUCE THEM

While retrocommissioning is cost effective for most buildings, it is important to understand its costs, as well as the strategies for reducing them, to ensure the greatest return. This section summarizes typical expected costs for a project and highlights cost-saving strategies.

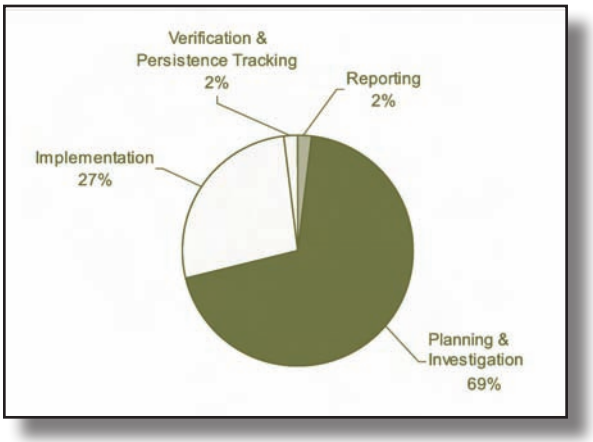
Costs

It is important to bear in mind that retrocommissioning costs, like the process itself, are unique to each project. Variables affecting both include:

- Scope of the project
- Number and complexity of systems
- Size of the facility
- Equipment age and condition
- Commissioning service provider rates
- Level of on-site staff knowledge interfacing with the project
- Presence of an extensive O&M program

The retrocommissioning provider's fee is the most obvious cost, but sometimes the cost of other team members (internal staff and/or outside contractors) participating in the process and that of correcting the identified problems are also included. Lawrence Berkeley National Laboratory's study of 100 existing buildings[6] (varying in type and

Figure 4. Commissioning Cost Allocation (Existing Buildings, N=55)

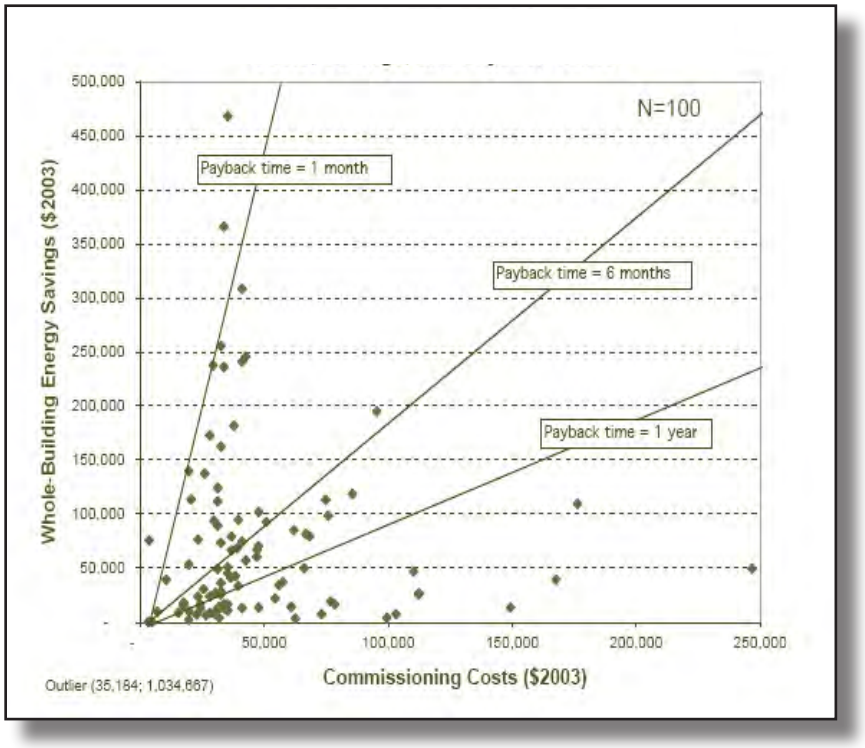


Source: Lawrence Berkeley National Laboratory, "The Cost Effectiveness of Commercial-Buildings Commissioning," December 2004. Represents $5.2 million for whole sample (2003 dollar).

6 Mills, E., H. Friedman, T. Powell, N. Bourassa, D. Claridge, T. Haasl, and M.A. Piette. 2004. "The Cost-Effectiveness of Commercial-Buildings Commissioning," Lawrence Berkeley National Laboratory. http: //eetd.lbl.gov/EMills/PUBS/Cx-Costs-Benefits.html

size) found that retrocommissioning provider fees ranged from 35 to 71 percent of total retrocommissioning costs, with a median value of 67 percent. The largest percentage of costs for a project was for investigation and planning phase activities (69 percent), followed by the actual implementation of measures (27 percent). See Figure 4 opposite. For the buildings in this study, the median investment in commercial retrocommissioning projects was $33,696, or about $0.27 per square foot in 2003 dollars (see Figure 5 below). On a square foot basis, total costs ranged from a low of $0.03 to a high of $3.86 per square foot.

Figure 5. Existing Buildings Commissioning: Cost, Savings, and Payback Times



Source: Lawrence Berkeley National Laboratory, "The Cost Effectiveness of Commercial-Buildings Commissioning," December 2004.

Budgeting for Retrocommissioning

Often, retrocommissioning will identify quick fixes that can be implemented without significant additional investment. For example, energy savings are commonly found by identifying equipment that is running when it is not needed. A simple change in the control system is all that it takes to capture these savings. The provider, however, may also identify measures that cannot be paid for in the current operations and maintenance budget. In these cases, the commissioning provider can assist in prioritizing improvements, and owners can actively plan in their upcoming budget cycles to accommodate the opportunity.

While it is possible to stage implementation of measures, it may not be cost effective to conduct a retrocommissioning investigation that does not continue on to implementation.

It is therefore advisable, where possible, to plan for the costs of larger measures from the start of the project, so that commissioning services can be most effectively utilized and the greatest savings realized. There may be financial incentives available from utilities and state programs, which will buy-down the cost of retrocommissioning. These incentives should be a factor in any analysis of the overall cost of the project and recoverable and non-recoverable expenses.

Case Study: Retrocommissioning at Marriott

The competitiveness of the luxury hotel industry requires hotel business owners to continuously work to increase revenue – which means aggressively pursuing lower operating costs. A retrocommissioning project at the hotel determined that reactivating the parking garage's demand controlled ventilation system could save hotel $60,000 in electricity costs per year. The full retrocommissioning project identified improvements with energy reduction potential of 8.4 % in Phase 1 of the project, and another 10.6% in potential savings for future implementation. Some additional benefits of the project included improvements to chilled water capacity, reduced chiller runtime (which will increase chiller life), documented operation and maintenance procedures, and training for the hotel's O&M staff.

"At Marriott, we've found that retrocommissioning saves us time and money. At one property, we expect to save nearly $500,000 annually in energy costs from implementing retrocommissioning measures - and the project will pay for itself in less than one year. We're using the [local utility] RCx program to continue our efforts in this area."
-E.J. Hilts, Regional Energy Manager for Marriott (Western Region)

Source: Portland Energy Conservation, Inc.

Strategies to Reduce Costs of Retrocommissioning

There are strategies that owners can use to reduce the costs of retrocommissioning and increase the effectiveness of the project. These include sharing costs with tenants and reducing retrocommissioning costs by involving building staff in the projects.

Cost Share with Building Tenants in Income-Producing Properties

Whether the costs associated with retrocommissioning are considered capital expenses or operating expenses determines if and how those costs can be shared with tenants (see p. 8).

Retrocommissioning as a Capital Expense

When retrocommissioning is undertaken in the context of an energy-saving capital improvement project, the cost of retrocommissioning may be rolled up into the cost of the project itself, and therefore be treated as a capital expense. In an income-producing

property, it may be possible to pass capital expenses through to tenants, depending on the type of lease in place (see p. 10).

Owners should be aware, however, of the implications involved in passing on the capital expenses of retrocommissioning. Doing so may limit recovery of the investment to a certain amortization schedule (e.g., the useful life of the equipment) or to the amount of savings actually realized by the tenant(s). If a lease limits pass-throughs to the amount of savings realized by the tenants, the owner may need to document the allocation of the project's savings between the building owner and each tenant. If the lease does not specifically address the topic of operating-expense reduction pass-throughs, the building owner could draft a lease amendment or simple side letter agreement that would allow the owner to recover energy savings investment costs from the tenants. Such amendments should contain quantitative evidence that the proposed capital project will produce savings for the tenants.

Retrocommissioning as an Operating Expense

The cost of retrocommissioning can also be considered an operating expense, since it focuses on improving the operation of energy-using systems. Again, lease terms will determine whether operating expenses can be passed along to the tenants. The circumstances driving an owner's decision to retrocommission will influence this decision. Where the purpose of retrocommissioning is to address tenant complaints about comfort or respond to abnormally high energy costs, the owner may choose to pay the full cost of retrocommissioning. In cases where the building's leases are "fixed-base" leases, and the owner anticipates a large amount of new leasing activity in the near future, the owner may opt to absorb the commissioning expense so that it will not raise the "base year" expenses that are factored into new leases. In other cases, the owner may include commissioning costs in tenant-reimbursed operating expenses, allocating the costs across two (or even three) years to minimize any distortion on base years for future leases. If investing in retrocommissioning and any related capital improvements would likely produce significant savings for all tenants, an owner might choose to claim a portion of the commissioning expense, and then pass the rest through to the tenants (along with the cost of any recommended capital improvements) to the fullest extent permitted by the lease.[7]

Involving Facility Staff to Save Time and Money

Leveraging facility staff's first-hand knowledge of the building can reduce the time needed by the provider to uncover building inefficiencies. There are many tasks that skilled staff can undertake to help streamline the process and increase the effectiveness of the commissioning provider's time.

7 Information summarized in part from the following publication: Jewell, Mark. RealWinWin, Inc. "Understanding the Value of Commissioning in Income-Producing Office Buildings," *Proceedings of the National Conference on Building Commissioning* (Palm Springs, CA, May 20 – 22, 2003).

Provide a List of Opportunities

Building operators know their buildings best and are often aware of the opportunities that exist for improving performance. During the initial phase of the project the facility staff should develop a list of existing potential improvements and known problems to share with the commissioning provider. This can help focus the investigation activities.

Gather Documentation

One of the first steps in retrocommissioning is to compile an up-to-date building documentation package including any written sequences of operation. Facility staff can assist with gathering available documentation. The more complete the documentation, the less time the commissioning provider needs to fill in the gaps. Often, documentation may not be available or the documentation that is available may not accurately reflect the current operating condition of the building or its equipment. If documentation is not up-to-date, building staff should, if possible, revise it prior to the initiation of the project or be prepared to discuss the undocumented changes with the commissioning provider. The provider should be given available documentation prior to the site visit, to allow them to learn as much as possible about the building ahead of time. At minimum, all building documentation should be made available on-site for the commissioning provider during the site visit.

Perform Scheduled Preventative Maintenance

Facility staff or an outside maintenance service contractor should complete scheduled preventive maintenance *before* the retrocommissioning Investigation Phase begins so the process isn't delayed by simple maintenance issues. Delays in the retrocommissioning process because of dirty filters, loose belts, broken dampers, or loose electrical connections can increase costs.

Assist with Diagnostic Monitoring, Trend Logging, and Functional Testing

It may be useful to have facility staff members assist with the short-term diagnostic monitoring, trend logging, and functional testing that occurs during the investigation phase of the project. This can reduce project costs, as well as provide the building staff with experience that they can apply later. If building staff are trained to initiate trend logs using the building's energy management control system (EMCS), a commissioning provider can reduce time spent on the task, and the owner will not need to hire a controls contractor for this task when the project is finished. Depending on availability, knowledge, and capabilities, facility staff also may be trained to assist with the installation and removal of portable data loggers used for short-term diagnostics and carrying out functional test plans. In addition to reducing costs, this exposes staff to different approaches for troubleshooting problems and investigating and verifying equipment performance. Observing diagnostic trending and testing will improve staff understanding of equipment and control strategies and enable them to retest or recommission systems periodically as part of the facility's ongoing O&M program.

Perform Repairs and Improvements

Retrocommissioning costs also can be reduced by using facility staff to perform repairs and improvements that would otherwise require outside contractors. The success of this approach hinges on staff training, knowledge, and time to carry out the work. Facility staff workloads should be assessed to determine how schedules and workloads might accommodate any additional work brought on by retrocommissioning.

Case Study: The Hatfield Courthouse

In 2003, the U.S. General Services Administration (GSA) initiated a full retrocommissioning (RCx) study of a federal Courthouse located in Portland, Oregon. The Hatfield Courthouse, built in 1997, has a total of 21 floors and a gross square footage of 591,689 sq. ft. The GSA's RCx goals included:

- Improve occupant comfort
- Identify O&M and energy efficiency improvements
- Train the building operators on how to help improvements persist
- Review and enhance building documentation

Investigation involved reviewing the building's documentation and utility bills, inspecting building equipment, interviewing building operators, testing selected equipment and systems, and extensive trending of the heating, ventilating and air conditioning (HVAC) control system. The investigation process identified 29 findings which addressed GSA's RCx goals.

The implementation process involved coordinating efforts among the commissioning provider, facility staff, and building services contractors. Twenty-three of the 29 recommendations to address these findings were implemented. This process resulted in a 10% reduction in energy use and significant improvements in building comfort and system operations.

Retrocommissioning increased the building's EPA energy performance rating from 65 to 75, allowing the building to receive an ENERGY STAR® label.

To ensure lasting benefits from retrocommissioning and achieve savings persistence, GSA is employing a "ongoing commissioning" approach.

The Numbers:

- Annual Utility Cost Savings: $56,000 (a 10% reduction of the facility's current utility expenditures) implemented, with $30,099 in energy saving improvements planned for future implementation.
- RCx Cost (investigation and implementation, including implementation project oversight costs): $172,459 - incentives and tax credits = $149,450
- Total RCx Cost: $0.25 per sq. ft.
- RCx simple payback: 2.7 years

Source: GSA and Portland Energy Conservation, Inc.

Selling Retrocommissioning from Within

Facility managers or directors may need to sell retrocommissioning to the building owner, property managers, or other senior level decision makers to get approval or "buy in" for the project. Managers faced with this challenge have a much better chance of generating support and obtaining the desired approvals if they present decision makers with a proposal that provides a solid business case for retrocommissioning.

An effective case for a retrocommissioning project clearly demonstrates how the benefits of retrocommissioning outweigh the costs. Thus, it is important that proposals for retrocommissioning present information that clearly lays out the project's estimated costs and benefits. A strong proposal also identifies cost reduction strategies when outlining the associated costs, and highlights how the energy savings and other benefits offer the owner a short payback period on the investment.

Keep the following points in mind when making the case for a retrocommissioning project:

Typical Benefits of Retrocommissioning:

- Identifies and addresses system inefficiencies that can cause the building owner and/or tenants to incur high operating and maintenance costs, as well as premature replacement costs.
- Improves the building's overall performance by optimizing energy-efficient design features and directly addressing issues like equipment performance and system integration.
- Helps drive down building operating expenses – generating a higher NOI and an increased asset value for the property.
- Reduces comfort complaints that lead to tenant turnover.
- Identifies potential indoor environmental quality issues and helps assuage occupant complaints.
- Ensures that building operations meet owner expectations.
- Provides benefits beyond energy savings which can generate associated revenue. These benefits include extended equipment life, improved thermal comfort and indoor air quality, labor savings, increased productivity/safety, and liability reduction.
- Verifies that building staff are well-trained and have the documentation they need to effectively and efficiently operate and maintain the building.
- Provides indirect cost savings and improvements – owners and building managers benefit from improved equipment performance and system operations, and building staff receive training and improved documentation.

Associated Costs of Retrocommissioning:

- Retrocommissioning provider's fee.
- Facility staff time and cost of including other professionals in the retrocommissioning process.
- Cost of correcting the problems identified by retrocommissioning.

- While costs vary depending on the complexity of the systems and project goals, recent studies show typical retrocommissioning project costs to be about $0.27 per square foot.[8]

Cost Reduction Strategies:

- Using facility staff to undertake tasks to help streamline the process and increase the effectiveness of the commissioning provider's time.
- Sharing costs with building tenants where possible under lease terms.

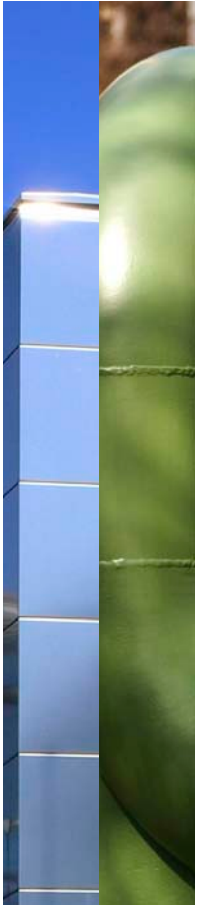
Demonstrating Cost-Effectiveness:

- Retrocommissioning costs are most often offset by energy savings. Energy-saving improvements can yield simple paybacks ranging from a few months to two years.
- It has been estimated that the dollar value of retrocommissioning non-energy benefits can offset the cost of a project by 50 percent.[9]

8 Mills, E., H. Friedman, T. Powell, N. Bourassa, D. Claridge, T. Haasl, and M.A. Piette. 2004. "The Cost-Effectiveness of Commercial-Buildings Commissioning," Lawrence Berkeley National Laboratory. http: //eetd.lbl.gov/EMills/PUBS/Cx-Costs-Benefits.html. Retrocommissioning costs include investigation and implementation.

9 Mills, E., H. Friedman, T. Powell, N. Bourassa, D. Claridge, T. Haasl, and M.A. Piette. 2004. "The Cost-Effectiveness of Commercial-Buildings Commissioning," Lawrence Berkeley National Laboratory. http: //eetd.lbl.gov/EMills/PUBS/Cx-Costs-Benefits.html. Data on non-energy benefits is from 10 buildings.

Chapter 2



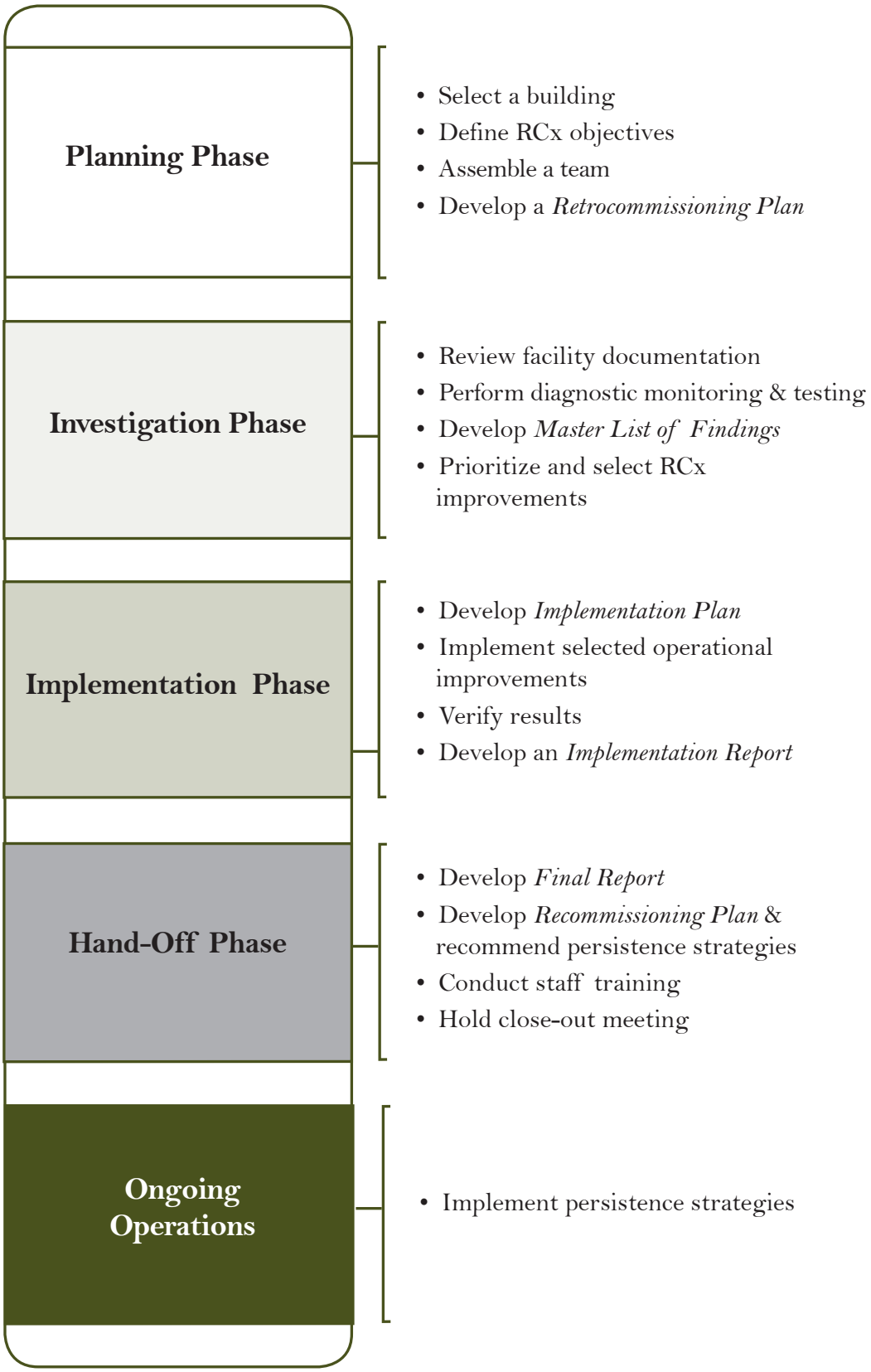
3. PROJECT BASICS

This section summarizes the steps in a retrocommissioning project, explains the various roles and responsibilities of the team members and culminates with a check list of "Key Strategies for Success." The purpose of this section is to distill the more detailed information that follows in order to give owners a quick understanding of the process and what key elements lead to a successful project with lasting benefits.

Highlights:

- Overview of the retrocommissioning process
- Roles and responsibilities of retrocommissioning team members
- Key areas for owner involvement
- Use of other outside contractors
- Key Strategies for Success

Figure 6: Retrocommissioning Process Overview



RETROCOMMISSIONING PROCESS OVERVIEW

A well-planned and executed retrocommissioning project generally occurs in four Phases: **Planning, Investigation, Implementation, and Hand-off** (as shown in Figure 6). These are followed by ongoing activities to ensure that benefits continue, often referred to as "persistence strategies." The more detailed **flow chart** (p. 41) at the end of this section outlines a typical retrocommissioning process and highlights the major work products (deliverables) coming out of the process. There is, however, no one-size-fits-all approach to retrocommissioning. Several factors affect how retrocommissioning may be executed – the condition of the facility, scope and budget of the project, size and complexity of the facility and availability of in-house resources and expertise. These differences do not commonly cause a project to divert significantly from the basic process.

Who is the "Owner"?

During the retrocommissioning process, the "owner" can be represented by any upper level manager with a vested interest in the project, a director or chief of engineering, or the property or facilities manager. In all cases, the owner's representative should be an active "champion," who is involved throughout the project and can secure the necessary senior management support to ensure that the project moves forward successfully. The owner should be a strong advocate for the retrocommissioning project; this support allows the project to progress smoothly, correct more building problems, and produce greater benefits.

BREAKING DOWN THE PROCESS

Phase 1: Planning

The primary tasks for the Planning Phase are to:

1. Screen potential candidate buildings for suitability, including analyzing the energy use per square foot and generating an initial benchmark score using the EPA energy performance rating system.
2. Select a candidate building.
3. Define goals and objectives for the project.
4. Select and hire a retrocommissioning service provider and assemble the team that will see the project through to completion.
5. Develop a retrocommissioning plan, including projected costs and savings associated with the project.

While the majority of buildings can benefit from retrocommissioning, this guide

provides tips on identifying those projects that will be the most cost effective. Owners and property management firms with building portfolios can look across their holdings to identify promising candidates for retrocommissioning. Determining factors include:

- The age and condition of a building and its equipment
- Existing known comfort problems
- Utility costs
- Lease agreements
- Potential for return on investment to owner
- Availability of utility and state incentive programs

Projects are usually led by a third-party commissioning provider with varying degrees of involvement by the building owner and staff. Some building owners and managers manage their own commissioning projects, bringing in a commissioning expert only for certain tasks. Chapter 4 discusses how to determine the most appropriate approach.

To develop a scope of work, the commissioning provider conducts an on-site visit, talks with O&M staff, and reviews current operating conditions at the facility. After gaining a clear understanding of project goals, the commissioning provider identifies opportunities for operational improvements in the building. The scope of work is a proposal negotiated between the commissioning provider and the owner that provides an outline of the processes and procedures to be undertaken; a schedule of activities; roles of team members; and sample forms and templates that the commissioning provider will use to document the retrocommissioning activities.

Phase 2: Investigation

The primary tasks of the Investigation Phase are to:

- Understand how and why building systems are currently operated and maintained,
- Identify issues and potential improvements, and
- Select the most cost-effective improvements for implementation.

The focus of Investigation activities depends on the scope and objectives of the project. Often, the commissioning provider looks at all aspects of the current operations and maintenance (O&M) program in the building, as well as the management structure, policies, and user requirements that influence them. Investigation tasks typically include:

- Interviewing management and building personnel
- Reviewing building documentation and service contracts
- Inspecting the building and its sub-systems and equipment components
- Spot testing equipment and controls
- Gathering and analyzing HVAC and lighting data
- Inspecting the building and its subsystems and equipment components

- Developing a list of recommended system improvements and estimated costs and savings associated with those improvements

The commissioning provider will produce a report for the owner at the end of the Investigation Phase, describing the specific findings uncovered and identifying potential costs and savings. The owner should discuss these findings with the provider and understand not only the payback period, but also associated non-energy benefits such as increased comfort. At this time, the owner selects which "retrocommissioning measures" to implement in the next phase.

Phase 3: Implementation

The primary tasks of the Implementation Phase are:

1. Implement selected measures
2. Update energy savings calculations as necessary
3. Verify that measures have been implemented correctly

In this Phase, the selected retrocommissioning measures and recommendations from the investigation report are implemented. Implementation can be carried out by the commissioning provider, building staff, or individual subcontractors. Most commonly, however, there is a mix of individuals involved, depending on staff availability and expertise, existing equipment warranties, existing maintenance contracts, the scope of work, and the budget.

Once the selected measures are implemented, the team needs to verify that they are performing as expected. The verification process should set a baseline for each improvement so that performance can be tracked to ensure the benefits persist.

Phase 4: Hand-Off and Implementation of Persistence Strategies

The primary tasks of the Hand-Off Phase are:

1. Complete a final report summarizing each improvement
2. Conduct facility staff training
3. Hold a project close-out meeting
4. Generate a post-retrocommissioning EPA energy performance rating
5. Develop persistence strategies including a recommissioning or ongoing commissioning plan

The Hand-Off Phase completes the retrocommissioning process. During Hand-Off, the commissioning provider produces a final report documenting the process and its findings, conducts facility staff training, and holds a project close-out meeting with the owner and facility staff. Persistence strategies should be put in place at this time to ensure the improvements last.

Chapter 3

THE STRUCTURE OF THE RETROCOMMISSIONING TEAM

The first responsibility of the owner's representative is to put together the retrocommissioning team. A team approach fosters the collaboration necessary to get the greatest impact from retrocommissioning.

Table 1. Typical Retrocommissioning Team Member Roles and Responsibilities

Participant	Roles and Responsibilities
Building Owner or Owner's Representative	Create and support team, provide information and resources needed for the project, clearly communicate goals and expectations.
Facility Staff	Ensure system maintenance is performed (e.g. belts are tight, equipment has been serviced, and sensors are calibrated) before systems are tested. Work with commissioning provider to perform tests and verify system operation.
Commissioning Provider	Assist in developing a scope of work. Identify measures and develop report detailing opportunities. Work with facility staff to perform tests and verify system operation. Assist the owner's team in developing scopes of work for the contractors implementing the measures.
Contractor or Manufacturer Representatives as needed	Perform work as outlined in existing service contracts that cover O&M of the building's HVAC, controls, and electrical systems. Test equipment and/or implement measures that pertain to the equipment they installed
Controls Contractor	Assist in setting trends and modifying the sequence of operations to meet test conditions if commissioning provider (or facility staff) is not familiar with the control system. Assist with implementation of controls-related fixes and improvements.
Design Professionals	Provide additional expertise regarding design issues uncovered during investigation. Assist in coordinating retrocommissioning with a retrofit project.
Testing Specialists	Assist the commissioning provider with complicated testing or with equipment that requires special expertise.

A team also facilitates open communication. This is essential to a successful project for the following reasons:

- Building staff often know which upgrades and O&M activities can improve building performance, but do not have the time to evaluate what it would take to make improvements or pitch a proposal to financial decision makers. Building staff can provide valuable information to the commissioning provider if retrocommissioning is approached as a collaborative process in which everyone brings skills and knowledge to the table.

- Involvement of the owner is critical to keep the project moving, achieve the greatest benefit, and ensure benefits last over time. Engaging with the team, clearly expressing project goals, and encouraging collaboration between the commissioning provider and building staff will all contribute to the successful implementation of the process.

In structuring the team, key decision makers should be clearly identified. This process is essential to implementing the improvements recommended as part of the retrocommissioning process.

Determining Roles

While the table above recommends general roles and responsibilities for team members, specific roles may shift as a result of budget limitations, unique building requirements, and facility staff expertise and availability. Finding the right balance between responsibilities for facility staff and the outside commissioning provider can be tricky and requires a good understanding of the capabilities of the individuals involved.

A third-party commissioning consultant is usually hired to lead the retrocommissioning effort. A building or facility manager, however, can manage the project and bring in a commissioning expert to assist with certain tasks. While it may be advantageous for the building staff to play a central role in a retrocommissioning project, having a commissioning expert provide 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. **Commissioning provider oversees and implements the retrocommissioning process through all phases.** This "turn-key" approach works well for owners who have one or more buildings with no on-site 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. **Commissioning provider leads the process, but divides assessment work with facility staff.** This arrangement works particularly well when facility staff has previous experience in commissioning, or has 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. **Commissioning provider works closely with facility staff on initial projects, and in-house staff proceed independently with future projects.** Owners with multiple buildings and well-trained and available 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 retrocommissioning the rest of the buildings.

4. **Commissioning provider works closely with facility staff on initial project and is retained as a consultant to perform advanced tasks on future projects.** This is similar to the third approach in that the in-house staff works to take on the role of the commissioning provider. In this approach, however, 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.

> CAUTION: While it may be tempting to have existing facility staff shoulder the majority of the retrocommissioning work, the key is to strike the right balance. If owners expect too much from staff, the process may stall or stop altogether. It may be helpful to think of the first retrocommissioning project as a skill-building opportunity for everyone, and to increasingly rely on in-house expertise with each successive project.

Good reasons to have a third-party commissioning provider lead the retrocommissioning process 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 significant experience to draw upon, enabling them to offer a fresh perspective on a building. A third-party provider has no preconceived notions about how the building should perform, and has no vested interest in maintaining the status quo.

- Commissioning providers are "tooled" for performing the work since they generally use data loggers, functional test forms, power monitors, and other specialized tools on a regular basis. Most have proven assessment and testing procedures that can be customized to fit a specific building.

- Engineering analysis is the specialty of the commissioning provider, who has the analytic skills and resources needed to diagnose hidden problems and determine the cost-effectiveness of selected improvements.

Table 2 shows the way roles were split for a large corporation with a highly experienced facility staff dedicated to the project. In this case, the energy manager developed an in-house retrocommissioning program to be used across all their facilities. The commissioning provider served as a consultant for testing systems, analyzing data, and training building staff throughout the process.[10]

10 Haasl, Tudi, 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*. World Energy Engineering Congress. (2004).

Table 2. Sample Breakdown of Roles and Responsibilities between In-House Facility Staff and Third Parties	
In-House Team	**Third Parties (Commissioning Provider and Subcontractors)**
Design program	Act as resource
Conduct EPA energy performance rating	Review – assist as needed
Utility bill analysis	Review – assist as needed
Gather building documentation	Review
Create maintenance checklists (scheduled preventive maintenance)	Focus and train staff on operational improvements
Assist provider in data gathering	Conduct functional tests and data analysis (look at the root cause)
Implement easy to fix improvements	Assist with resolving design and complex implementation issues
Provide ongoing tracking and preventive maintenance	Provide ongoing support as needed
Obtain approval to implement improvements	Assist staff in developing the implementation proposal to upper management

Involving Facility Staff

While some building owners or managers may be tempted to undertake retrocommissioning in-house, others may find it just as enticing to bring in an outside provider to carry the entire burden of the project. If the facility staff is excluded from the process, however, owners may miss an opportunity that can lower the project budget, increase in-house expertise, and extend the impact of the improvements.

Facility staff can complete many supporting tasks without specialized training in this process. Gathering and analyzing utility bills, benchmarking the building's performance, and performing a maintenance tune-up are generally straightforward and can be addressed with guidance from a commissioning provider. Implementing improvements may also be accomplished by in-house staff, depending on their expertise. See **p. 19** for specific detail on how owners can use in-house staff as a cost-saving strategy.

Participating in the retrocommissioning process can provide facility staff with a better understanding of the building's systems and their interactions. To capture this benefit, building owners need to allocate adequate staff time and budget for retrocommissioning work in addition to regular job duties.

Outsourced O&M Services

Some owners do not have full- or part-time building operators, while others may employ building operators with minimal skills or time. These owners often use service contracts to cover the O&M of 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 asked to perform certain scheduled preventive maintenance tasks to prepare a building for retrocommissioning, as well as to assist in data gathering, performing hands-on testing, and adjusting and calibrating equipment.

Additional Team Members/ Contractors

In some retrocommissioning projects it is important to involve additional outside contractors (installing contractors, maintenance service contractors, controls contractors, and manufacturers' representatives). This usually occurs if equipment is still under warranty or under contract for service, as is often the case for control systems and large plant equipment such as chillers and boilers. Where equipment is under warranty, the contractor should be involved *early* in the retrocommissioning process to prevent the voiding of warranties that could occur if an outside party manipulates the equipment. Installing contractors and manufacturer representatives may need to be brought in for equipment testing and/or implementation of measures on the equipment they installed.

Controls Contractor

Frequently, the person most familiar with the building's control sequences and programming is an outside controls contractor. A significant percentage of retrocommissioning findings are likely to address opportunities to reduce costs by improving the building's control strategies. Although it can be expensive, the expertise in trend logging and programming a control technician offers is essential and, in most cases, well worth the expense.

Design Engineers

If retrocommissioning is undertaken in conjunction with new equipment installation, then the engineers responsible for designing the equipment and systems should be involved. Design engineers also should be involved when the commissioning provider needs additional expertise regarding design issues that are uncovered during investigation. Ideally, the engineer who designed the original installation should be brought in as a consultant to help resolve issues. The original design engineer also may have system documentation that is missing from the building's files.

Testing Specialists

Some commissioning providers are also test engineers fully-equipped to perform almost any test required. This, however, is not always the case. Many providers are skilled at performing HVAC functional tests and calibration exercises, but rely on other professionals or test experts

for equipment that requires special expertise, such as variable-volume fume hoods. It may be particularly necessary to bring in specialized HVAC and testing and balancing experts in order to document air and water flow rates. The provider should be able to help identify qualified specialists. The commissioning provider also typically writes the test procedures or goals for the testing exercise and then the testing is completed by the appropriate specialist.

LEED Coordinator

If a retrocommissioning project is part of a LEED-EB project, then the provider and project team will need to work closely with the LEED project coordinator. The LEED coordinator is responsible for compiling documentation needed to support achievement of credits required for the LEED certification. The retrocommissioning team needs to provide information related to the retrocommissioning process, and confirm that the retrocommissioning project is complete, or that the facility has a plan in place to complete it.

KEY STRATEGIES FOR SUCCESS

The following section summarizes strategies described in detail later in the Guide. These are areas that a building owner or owner's representative should pay particular attention to while designing and carrying out a retrocommissioning project. Each Key Strategy contains a link/reference to the corresponding detailed sections on each strategy. In addition, the Key Strategies section summarizes the deliverables that owners will want to obtain from their commissioning provider, along with links to examples that are located either in the appendices to this guide or on the web sites of organizations such as the California Commissioning Collaborative (**www.cacx.org**).

Note: If readers are using the electronic version of this document, you may easily return to "Key Strategies for Success" by clicking on the ◀ Back to KEY STRATEGIES button, located at the bottom of the linked page(s).

Identify the Best Building Candidates

Owners of multiple buildings can consider a portfolio approach to selecting the best candidate(s) for retrocommissioning. Evaluating potential for energy improvements across a portfolio of buildings and selecting those with the most potential for success in the retrocommissioning process can assist with long-term planning and enable the owner to strategically capitalize on short-term paybacks. When budgets are tight, it may be wise to start with buildings in areas where utility incentives are available. Read more about **Good Candidates for Retrocommissioning** (p. 44). See an example in **Appendix A – List of Preferred Building Characteristics for Retrocommissioning.**

Checklist Items for the To Do List

- ☐ *Analyze the building portfolio to identify the best retrocommissioning candidates. Bear in mind that the worst performing buildings in a portfolio may not be the most cost effective choices.*

Develop Well-Defined Objectives

The owner's project objectives determine the overall vision, scope, and direction of the project. They should be written and clearly articulated to the commissioning provider to guide the project from start to finish. Understanding the objectives helps to ensure that adequate time and funds are allocated to complete the project. Read more about **Defining Objectives and Project Scope** (p. 48).

Checklist Item for the To Do List

- ☐ *For each building selected, write a set of objectives that can be incorporated into the Retrocommissioning Plan and the retrocommissioning provider's scope of work.*

Select a Commissioning Provider Well-Suited to the Project

When hiring a provider, check general qualifications such as years in the field, but, most importantly, understand what experience each candidate has with your specific building type. Ask to see sample reports to understand the type of information you can expect during the project. Read more about **Selecting a Commissioning Provider** (p. 52).

Checklist Item for the To Do List

- ☐ *Develop a Request for Proposal (RFP) or a Request for Qualifications (RFQ) for retrocommissioning the selected building or buildings. The RFP should clearly define the project and its objectives.*

Designate an In-House Champion

Owner commitment is critical to project success. From the beginning, engaging with the team to clearly express project goals and support collaboration between the commissioning provider and building staff helps ensure a successful retrocommissioning project. If the owner cannot be directly involved, the next best strategy is to assign an owner's representative to be an active "champion" for the project. This person will need to rally the facility staff to action and secure the necessary senior management support to keep the project moving forward. Read **Owner Support and the In-House Champion** (p. A-3) and **Determining Roles** (p. 31).

Checklist Item for the To Do List

- ☐ *Assign the appropriate in-house staff person to shepherd the project. Ensure that assigned staff have adequate time to oversee the provider and carry out some retrocommissioning tasks where necessary.*

Assign Key Facility Staff

Assign key facility staff to work with the commissioning provider throughout the retrocommissioning project. When facility staff are brought in and consulted from the beginning, potential conflicts are avoided. A retrocommissioning process involving experienced, knowledgeable, interested, and available building staff is more likely to be cost-effective and have lasting results. There a several points in the retrocommissioning

process where facility staff involvement can reduce costs and increase benefits. Read more about **Involving Facility Staff to Save Time and Money** (p. 19) and **Involving Facility Staff** (p. 33).

Checklist Item for the To Do List

☐ *Assign one or two experienced building operators (especially those who have the most controls experience) to work with the commissioning provider. Request that the commissioning provider provide estimates for the timeframe and necessary level of staff involvement for each task.*

Define Project Deliverables

As part of the commissioning provider's contractual scope of work, include a well-defined list of deliverables or outcomes for each phase of the project. The detailed **Retrocommissioning Flow Chart** (Figure 6) on page 26 shows where each deliverable typically occurs during the process. These documents may include:

Planning Phase

- Retrocommissioning Plan
  - Read **The Retrocommissioning Plan** (p. 56)
  - See an on-line example at the **CCC website (www.cacx.org)**

Investigation Phase

- Owner's Operating Requirements
  - Read **Owner's Operating Requirements** (p. 60)
  - See an example in **Appendix B – Owner's Operating Requirements** (p. B-1)
- Diagnostic Monitoring and Functional Test Protocols
  - Read **Diagnostic Monitoring and Functional Testing** (p. 61)
- Findings Log
  - Read **Develop a Findings Log** (p 65)
  - See an on-line example on the **CCC website (www.cacx.org)**
- List of improvements selected for immediate implementation
  - Read **Prioritize and Select Operational Improvements** (p. 65)
  - Investigation Report
  - Read **Develop the Investigation Report** (p. 65)

Implementation Phase

- Implementation Plan
  - Read the **Implementation Plan** (p. 70)
  - See an example in **Appendix C – Retrocommissioning Implementation Plan** (p. C-1)
- Implementation Report
  - Read **Implementation and Verification Reporting** (p. 70)
  - See an example in **Appendix D – Retrocommissioning Implementation Report** (p. D-1)

Hand-Off Phase

- Final Report
  - Read **The Final Report** (p. 74)
  - **See an example on-line**
- Systems Manual
  - Read **Enhanced Documentation** (p. 80)
  - See an on-line example on the **CCC website (www.cacx.org)**

Strategies for Ensuring Persistence

- Recommissioning or Ongoing Commissioning Plan
  - Read **Recommissioning** (p. 84) or **Ongoing Commissioning Plan** (p. 85)

The **Resources** section (see p. 87) provides links to sources for templates of many of the above listed documents, as well as other documents that may be useful to the owner in the retrocommissioning process.

Checklist Item for the To Do List

☐ *Include a list of detailed deliverables in the commissioning provider's scope of work. Consult the "Resources" section of this guide to help develop the list of deliverables.*

Hold a Project Kick-off Meeting

The retrocommissioning kick-off meeting is typically scheduled prior to the Investigation Phase. In this meeting, it is critical to clearly outline the benefits of participating in the retrocommissioning project to get buy-in from each team member. A formal project kick-off meeting creates an opportunity to bring the project team together to review the Retrocommissioning Plan and discuss the objectives, process, and team roles. Read **Project Kick-Off Meeting** (p. 60).

Checklist Item for the To Do List

☐ *Schedule time to attend the Project Kick-off Meeting. Review the agenda with the commissioning provider prior to the meeting.*

Define the Owner's Operating Requirements

Providing detailed operating requirements for the facility enables the commissioning provider to be sensitive when performing diagnostic activities to ensure that the critical operating requirements of the building are not disturbed. These requirements are also useful to the provider in assessing the feasibility of retrocommissioning measures. The owner's operating requirements inform the commissioning provider of building schedules, functions, and processes, and differentiate between areas of the building that have different uses. Read **more** (p. 60).

Checklist Item for the To Do List

☐ *Develop a written list of operating requirements for the building as early in the project as possible. Review lease agreements for tenant operating needs to ensure that they are taken into consideration during the investigation process.*

Accomplish Strategic O&M Tasks Prior to the Investigation Phase

Prior to the Investigation Phase, direct the building staff to gather the most up-to-date building documentation such as mechanical and electrical drawings, equipment lists, O&M manuals, and sequences of operation. This will expedite the project by saving the commissioning provider time. Also, direct the building staff to complete all scheduled maintenance prior to the Investigation Phase. Normal equipment maintenance should be completed before assessing equipment and system performance. Because this does not require a commissioning provider's expertise, it is more cost effective to have in-house staff or an outside service contractor address these tasks early to prevent delays in the project. Read **Performing Scheduled Preventative Maintenance** (p. 20).

Checklist Item for the To Do List

- ☐ *Make a list and assign strategic O&M tasks to the building operations staff and service contractors to help expedite the retrocommissioning work.*

Review the Findings Log with the Commissioning Provider

The Findings Log and Investigation Report are the most significant deliverables coming out of the Investigation Phase of the project. The Findings Log can be thought of as a decision-making tool for the owner. The owner and commissioning provider use the Findings Log to select and prioritize the operational improvements for the most cost-effective results. Read **Develop a Finding Log** (p. 65).

Checklist Item for the To Do List

- ☐ *Schedule a meeting with the commissioning provider to review and select the improvements for implementation based on information in the Findings Log. This meeting should include any building staff members who were intimately involved in the investigation process.*

Select an Implementation Approach

Depending on the building and circumstances of the project, there are different approaches to consider for implementing the retrocommissioning measures. The approaches range from "turn-key," where the commissioning provider is hired to manage the entire process from start to finish, to using in-house staff to manage the entire implementation phase. Choosing an implementation approach will largely hinge on the in-house staff's availability and skills. Read **Selecting an Implementation Approach** (p. 68).

Checklist Item for the To Do List

- ☐ *Assess the in-house building staff's abilities and time constraints, prior to determining the implementation approach. If appropriate, implementation can be staged to take advantage of utility incentives, lease changes, and budget cycles.*

Require or Develop an Implementation Plan

This document is critical for helping the implementation proceed smoothly and should reflect the management approach selected for the Implementation Phase. It should include scopes of work for addressing all the selected measures, as well as the methods required for evaluating the results after implementation. Read **The Implementation Plan** (p. 70).

Checklist Item for the To Do List

- ☐ *Review the Implementation Plan for each of the selected retrocommissioning improvements. Confirm that verification requirements are included to prove that each of the improvements is functioning as expected.*

Require an Implementation Report

The Implementation Report, and the data it contains that verify the impact of measures, is a key document. This is used for staff training, maintaining continuous building performance, and project evaluation. Read the **Implementation Verification and Reporting** (p. 70).

Checklist Item for the To Do List

- ☐ *Review the Implementation Report to make sure it is clear as to what was implemented and that it was verified to be implemented correctly. The approved report should be made available to those building staff members who are responsible for maintaining the improvements.*

Require a Final Report and Hold a Project Close-Out Meeting

Developing the Final Report is a key responsibility of the provider. It is the comprehensive record of the retrocommissioning project and should be kept as part of the on-site resources for facility staff. The owner should request that the provider present the Final Report at a Project Close-Out Meeting, in order to address questions from staff and management about the project process, findings, and deliverables. Read **more** (p. 74).

Checklist Item for the To Do List

- ☐ *Schedule the Project Close-out Meeting to reiterate the project accomplishments and go over next steps for ensuring the benefits last.*

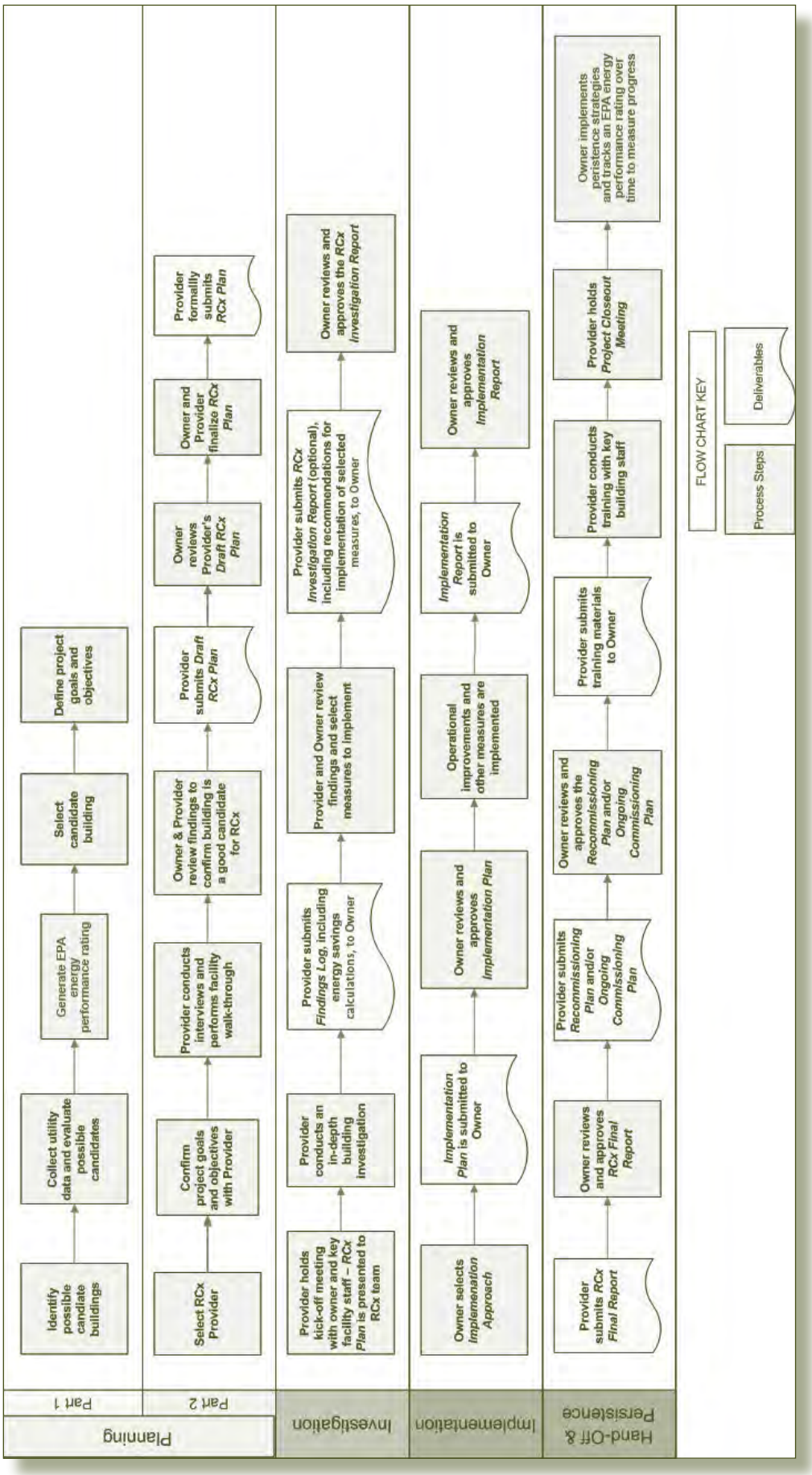
Develop Persistence Strategies

During the retrocommissioning Hand-off Phase the owner and commissioning provider determine effective persistence strategies for ensuring the retrocommissioning benefits are long lasting. Without these strategies the new, more efficient measures and improvements may degrade quickly. The commissioning provider can recommend which strategies are most appropriate for the building and help develop a plan to carry them out. Read **more** (p. 75).

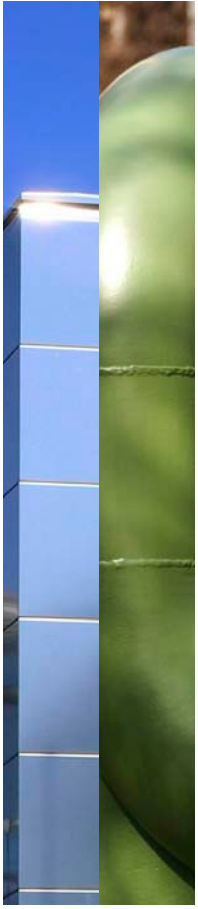
Checklist Item for the To Do List

- ☐ *Determine methods for incorporating persistence strategies into the building's O&M plan. These methods should include, at a minimum, periodic O&M reviews for those improvements most at risk for degradation.*

Figure 7. Retrocommissioning Process Flowchart



Chapter 3



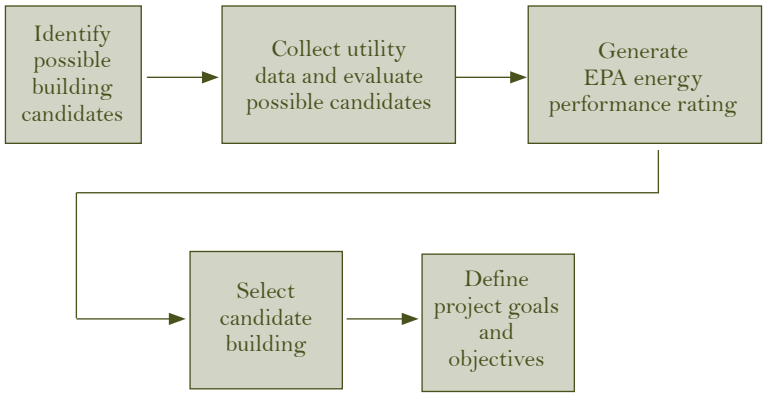
4. PROJECT PLANNING – PART 1

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's efforts. This section helps the owner's representative determine which buildings are good candidates for retrocommissioning and provides guidance for defining an appropriate scope for a project. A commissioning provider can be hired to assist with building selection and formation of project objectives, or can be selected after the project is defined internally. The next chapter, Project Planning-Part 2, provides guidance on selecting a commissioning provider and initiating the retrocommissioning project.

Highlights:

- Selecting a building for retrocommissioning
- Coordinating with retrofits
- Setting project objectives and obtaining support

Figure 8. Retrocommissioning Process Flowchart: Planning - Part 1



Chapter 4

GOOD CANDIDATES FOR RETROCOMMISSIONING

There is usually room to improve a building's performance regardless of its age, purpose, or size. Not every building, however, is appropriate for retrocommissioning. The first task is to determine which building or buildings are the best candidates. Newer buildings that were never commissioned often provide the most energy savings and non-energy benefits at the lowest cost. A good retrocommissioning provider can help determine which buildings in an owner's portfolio have the greatest potential to yield benefits.

What makes a good candidate for retrocommissioning?

Obvious indicators of a good retrocommissioning candidate include:

- Unjustified high energy use index (Btus/square foot) or unexplained increases in energy consumption.
- Persistent or premature failure of building equipment, control systems, or both.
- Excessive occupant complaints about temperature, air flow, and comfort.

Note: Because buildings are complex and energy waste is often hidden, many buildings that exhibit none of the above characteristics may still prove to be good candidates for retrocommissioning. Experienced commissioning providers understand how to uncover hidden energy waste that can lead to significant cost savings.

When is retrocommissioning not the first step?

Retrocommissioning may not be appropriate for buildings where:

- Most of the equipment and systems are either outdated or at the end of their useful life and need to be replaced. In this case, "end of their useful life" means that equipment will need replacing in three years or less and retrocommissioning will not improve these odds.

- Major system design problems exist. *Note:* Care should be taken in determining this as controls malfunctions may initially be diagnosed as design flaws.

CAUTION: Owners often want to retrocommission their worst performing buildings first, but these facilities are not necessarily cost-effective choices.

◀ Back to KEY STRATEGIES (p. 35)

Other Characteristics to Consider

There are several other building characteristics that may predict a project's chance of success and increase its cost-effectiveness. These characteristics include:

- **Size.** Though larger buildings are often thought to be better retrocommissioning candidates, a building of any size with complex mechanical systems and controls would be a good choice for a retrocommissioning project.

- **Building controls.** Although buildings with fully pneumatic controls have good retrocommissioning opportunities, buildings with computerized energy management control systems (EMCS) or hybrid systems (part pneumatic and part computerized) are typically more cost effective. Pneumatic controls easily drift and need constant attention and calibration for benefits to last. Also, because of its trending capabilities, an EMCS can be used as a diagnostic tool during the retrocommissioning process to capture data, reducing the number of data loggers needed.

- **In-house staff.** Retrocommissioning performed in buildings with experienced, knowledgeable, interested, and available building staff is more likely to be cost-effective and have lasting results.

- **Building documentation.** While having missing or out-of-date building documentation should not eliminate a building from consideration, in the interest of cost effectiveness, owners may wish to conduct retrocommissioning first in those buildings with better documentation. Complete, well-organized documentation can expedite the investigation process.

Appendix A provides a detailed sample list of preferred building characteristics.

Portfolio Approach to Building Selection

Owners of multiple buildings (private building owners, investment trusts, and property management firms) can consider a portfolio approach to selecting the best candidate(s) for retrocommissioning. Evaluating energy improvement potential across a portfolio of buildings and selecting those with the greatest likelihood for success can assist owners with long-term planning and enable them to capitalize on short-term paybacks. To begin with, an owner can look at energy records to determine how energy costs per square foot have increased over the years and compare it with other properties of similar age and use. Owners may choose to have a commissioning provider conduct a study of all their facilities to support development of a multi-year retrocommissioning plan. At a minimum, owners should develop a system to understand, compare, and prioritize their building stock to determine which sites present the best opportunity for retrocommissioning. The EPA *Portfolio Manager* on-line tool is also an effective resource that owners can use to help prioritize their buildings.

◀ Back to KEY STRATEGIES (p. 35)

EPA Energy Performance Rating

The EPA energy performance rating system allows building owners and managers to compare a building's performance to other similar buildings, and look at energy across a portfolio of buildings. EPA's *Portfolio Manager* on-line tool is a publicly available, web-based resource that facilitates this process. *For further information, visit* **www.energystar.gov/benchmark**.

Portfolio Manger is a widely used building tracking and energy rating tool. Building information needed for the tool is minimal and easily entered on-line in an account that owners can create and manage for their buildings. Select energy service providers and utilities also offer to establish and update accounts for customers. All information entered by owners is confidential. *Portfolio Manager* uses the EPA energy performance rating system to score buildings on a scale of 1 to 100 using energy bill data and building characteristics. The tool accounts for factors that affect energy use, including climate, occupancy level, hours of operation, and space use. The rating received by a building reflects how its performance compares to similar buildings. A score of 75, for example, means that a particular building outperforms approximately 75 percent of its peers. Buildings with a score of 75 or higher are eligible to receive the ENERGY STAR® label – signifying their outstanding level of performance. Retrocommissioning can help increase a building's energy performance rating.

Working with a Commissioning Provider to Select a Building

A commissioning provider can be brought in early in the decision-making process to assist in identifying a building well-suited for retrocommissioning. A provider can evaluate buildings in more detail than is possible using only a benchmarking score and can estimate the opportunity for reducing costs. The information a commissioning provider uses to analyze sites includes:

General information:

- Building type
- Number of occupants
- Size (gross square feet)
- Annual hours of operation
- Year of construction
- Year of last renovation
- Mechanical, lighting and control systems (types and sizes)

◀ Back to KEY STRATEGIES (p. 35)

Energy data (ideally, three years worth):

- Annual electricity use (kWh/year)
- Peak demand
- Annual natural gas use
- Annual district heating or cooling
- Average annual energy use index (EUI) for region/city for similar type building (Btus/square foot)

Operations overview:

- HVAC schedules relative to operating hours
- Set points
- Minimum outside air ventilation rates
- Extent of variable flow systems
- Preliminary discussions with facility staff members

Simulation of building optimal energy consumption:

- Optimal monthly electrical demand and energy consumption
- Differences between optimal and real data

A commissioning provider also can review energy contracts and offer recommendations about how the owner might be able to negotiate these costs with an energy provider.

Once documentation is gathered, the commissioning provider generally conducts a preliminary "walk through evaluation" of the top building candidates to make the final recommendation on which buildings are the best candidates for retrocommissioning.

Coordinating Retrocommissioning and Retrofits

As mentioned above, a building is not a good retrocommissioning candidate if most or all of its equipment has aged to a point where retrocommissioning can not produce improvements that would avoid equipment replacement. If only some equipment needs to be replaced, however, this can be coordinated with retrocommissioning to maximize benefits. Incorporating retrocommissioning with the replacement process improves system performance by ensuring that new equipment is properly integrated with other building systems. This assumes that the new installation is commissioned as part of the retrocommissioning project. In the interest of cost and continuity, the same commissioning provider can be hired to do both the new-installation commissioning and the retrocommissioning processes.

Information on retrocommissioning and energy saving performance contracts can be found in **Appendix F**.

◀ Back to KEY STRATEGIES (p. 35)

Chapter 4

DEFINING OBJECTIVES AND PROJECT SCOPE

Once a building is identified as a candidate for retrocommissioning, the building owner needs to define objectives for the project. A good provider can help an owner define these objectives. Owners may therefore want to take advantage of provider expertise early in the Planning Phase.

The following list provides some example objectives:

- Work with building operators to identify and recommend improvements to operational strategies and maintenance procedures, focusing on those measures that sustain optimal energy performance and reduce operating costs.
- Identify problems that could compromise the building's indoor environmental quality such as air quality and comfort.
- Train building staff during the process on how to best gather and analyze data to help troubleshoot and identify problems and improvements to operating procedures.
- Develop recommendations for improving building documentation.
- Identify possible capital projects for further investigation that can lead to energy cost savings.
- Assist management with developing language for lease agreements that prevents tenants from overriding sustainability and energy-efficiency measures.

Once the objectives are defined, it is important for the owner to actively garner the support of upper management and facility staff in accomplishing these tasks. Internal commitment to project objectives is a critical component of a successful retrocommissioning project. This support helps to ensure that the process is completed on time and that savings and improvement opportunities are pursued.

The project scope can be developed with the assistance of a commissioning provider, as explained above, or can be developed in preparation for hiring a commissioning provider. Once developed, the project scope helps define the provider's Scope of Work as described in the Proposal for Services. The project scope should include the following:

- Project objectives
- Buildings, building systems, and equipment that will be part of the assessment
- Anticipated level of involvement from in-house staff in the process
- Timeframe for investigation completion
- Number and type of expected deliverables or work products resulting from the process

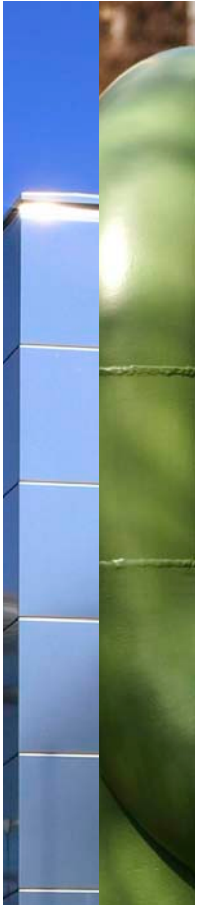
◀ Back to KEY STRATEGIES (p. 35)

Once the scope of the project is defined, the owner can decide more precisely how to involve facility staff in the project. It is important that the owner consider in-house staff expertise and availability, given the project's scope and complexity. If facility operators are new to retrocommissioning, the first project can be used as a skill-building opportunity for everyone. Successive projects can potentially rely more and more on in-house expertise.

◀ Back to KEY STRATEGIES (p. 35)

Chapter 4

◀ Back to KEY STRATEGIES (p. 35)



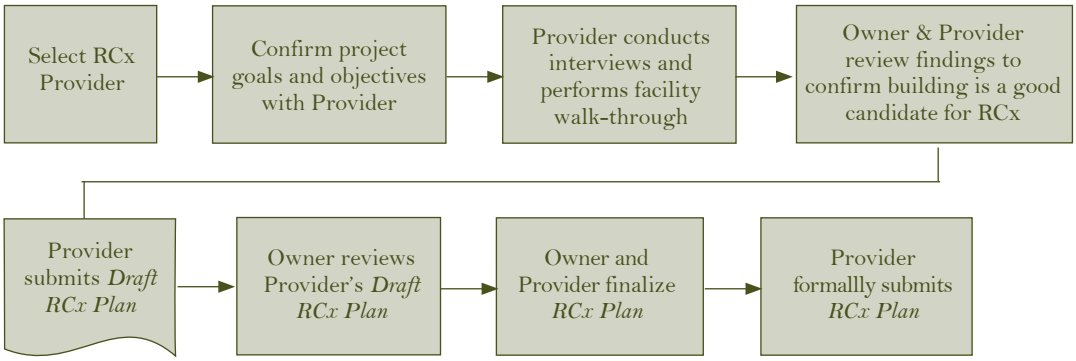
5. PROJECT PLANNING – PART 2

This section describes how to select the appropriate commissioning provider and explains the primary activities that occur during the beginning phase of a project. Once on board, the commissioning provider conducts a preliminary walk-through evaluation. Based on initial findings in the building and a clear understanding of project goals, the commissioning provider develops the Retrocommissioning Plan. The Retrocommissioning Plan serves as a guideline for team members to follow.

Highlights:

- Selecting a retrocommissioning provider
- Provider certification programs
- Qualities to look for in a retrocommissioning provider
- Preparing for a building walk-through
- What to expect in a Retrocommissioning Plan

Figure 9. Retrocommissioning Process Flowchart: Planning - Part 2



◀ Back to KEY STRATEGIES (p. 35)

Chapter 5

SELECTING A COMMISSIONING PROVIDER

In most cases, 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 has a depth of troubleshooting experience, as well as the diagnostic monitoring, testing, and analysis expertise needed to uncover potential problems and select the most cost-effective solutions.

Retrocommissioning Tasks

While roles and responsibilities vary, the retrocommissioning provider's tasks typically include the following:

- ✓ Perform an initial site walk-through and gather general information about the building.
- ✓ Assist owner in developing a scope of work based on information from the site visit.
- ✓ Develop the Retrocommissioning Plan based on owner's goals for the project and findings from the initial site visit and information gathering.
- ✓ Facilitate the project kick-off meeting.
- ✓ Review existing building documentation.
- ✓ Perform a detailed on-site assessment of the current O&M practices.
- ✓ 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.
- ✓ Calculate energy savings and assist the owner with prioritizing the most cost-effective improvements for implementation.
- ✓ Develop Retrocommissioning Investigation Report that summarizes findings and provides recommendations for implementation of selected measures.
- ✓ Prepare the Implementation Plan.
- ✓ Assist with or oversee implementation of the selected improvements.
- ✓ Compile verification data by performing post-implementation monitoring and testing activities to verify proper operation.
- ✓ Recalculate energy savings based on before and after short-term energy measurements.

◀ Back to KEY STRATEGIES (p. 35)

Retrocommissioning Tasks (continued)

- ✓ Submit the Retrocommissioning Final Report (a summary of the entire project and O&M guidelines for each measure)
- ✓ Provide building operator training on the implemented measures and how to ensure improvements persist over time.
- ✓ Develop a Recommissioning or Ongoing Commissioning Plan for the owner.

Provider Qualifications

When reviewing a commissioning provider's qualifications, it is important to consider his or her technical knowledge, relevant experience, availability, and communication skills.

Certification

Certification is one metric that owners can use to select a qualified commissioning provider. The rigor of certification varies by certifying agency. There are five organizations that currently certify commissioning providers – each with its own set of requirements and a different title for the providers it certifies. Consult the organizations' websites for more information on certification programs and to obtain lists of certified commissioning providers:

- **Certified Commissioning Professional** (CCP) – Building Commissioning Association (BCA), **http://www.bcxa.org**
- **Certified Commissioning Provider** – Associated Air Balancing Council Commissioning Group (ACG), **http://www.commissioning.org**
- **Accredited Commissioning Process Provider** – University of Wisconsin, Madison (UWM), **http://epdweb.engr.wisc.edu**
- **Systems Commissioning Administrator** – National Environmental Balancing Bureau (NEBB), **http://www.nebb.org**
- **Certified Building Commissioning Professional** (CBCP®) – Association of Energy Engineers (AEE), **http://www.aeecenter.org**

Appropriate Experience and Technical Knowledge

Whether a potential commissioning provider is certified or not, it is critical that the provider have the right experience and technical knowledge for the owner's project (certification doesn't guarantee that). Owners should consider how many years of experience a commissioning provider has in designing, operating, troubleshooting, and testing building systems, including HVAC, direct digital controls (DDC), electrical power, lighting, and life safety. Owners should also look for providers with the ability to provide operation and maintenance training. The significant role that HVAC systems play in retrocommissioning means that a provider must have adequate HVAC and controls experience in order to ensure a successful outcome. Provision of documented references is essential as a proof of experience.

◀ Back to KEY STRATEGIES (p. 35)

Because every project is unique, it is important to select a provider whose expertise and experience closely aligns with the project's objectives, scope, and complexity. For example, if improving indoor environmental quality (IEQ) is the primary objective for retrocommissioning, then the individual or firm hired for the job must be skilled at investigating and solving IEQ problems. If retrocommissioning is being implemented to reduce risk, owners should determine where their buildings are most at risk and if they do not perform as expected. An owner should then select a commissioning provider who brings technical knowledge specific to that particular building function to the project. For example, an owner of a laboratory may need a commissioning provider with experience verifying biological containment systems.

Availability and Communication Skills

Look for a commissioning provider that will be available when needed. Consider physical distance from or convenient travel to the facility site; although, for critical facility types it is more important to have the right technical skills than to select a provider that is physically nearby. Also, since the provider must interact with a wide range of people (owners, building operators, contractors, and manufacturer representatives), it is essential that the provider has strong communication skills.

The Selection Process

Two primary methods used for selecting a commissioning provider are the *Request for Proposals (RFP)* and *Request for Qualifications (RFQ)* processes. Most government entities and many corporate owners may be required to use one of these processes.

Selection by Proposal

In a competitive selection process, the owner issues a Request for Proposals (RFP). This process solicits qualifications and a detailed scope of work from potential commissioning providers and requires the owner to carefully evaluate each submission. Using an RFP process may be the most appropriate method to select the provider if the project is large or fairly complex. Many public agencies are required to go with the lowest qualified price proposal and should, if using an RFP process, carefully define the minimum qualifications and requirements.

Selection by Qualification

A provider can also be selected by evaluating qualifications and rate schedules, without first developing a detailed scope of the work and price proposal. Using a Request for Qualifications (RFQ) is often simpler than the RFP process, but it does require the owner to carefully evaluate the providers' qualifications and interview past clients and references.

Appendix E presents a checklist of items to consider when developing a request for retrocommissioning services.

◀ Back to KEY STRATEGIES (p. 35)

Most projects require providers to prepare their proposals in two phases. It will be difficult for the commissioning provider to assess the time required for tasks in the Implementation and Hand-off Phases without first completing the Planning and Investigation Phases. Similarly, owners may not know how they want to handle the implementation without first receiving the investigation findings. Retrocommissioning providers may request to initially offer a specific proposal only on the planning and investigation phases of the project. Negotiations for the implementation and hand off phases would then occur when more is known about the specific needs of the project. This approach helps the commissioning provider offer a more comprehensive and accurate cost estimate and a realistic scope of work.

THE BUILDING WALK-THROUGH

A commissioning provider will conduct a walk-through of the facility, with the opportunity to talk to building staff, before developing a scope of work and Retrocommissioning Plan. A building walk-through allows the provider to become familiar with the building, its equipment, and main energy-consuming systems, as well as identify opportunities for further investigation. The building walk through may be conducted as part of the proposal process, since the information gained will assist the provider in developing a Proposal for Services. A provider can learn a lot about the building by observing the overall condition and operation of the equipment, and the positions of valves and dampers. As part of the walk-through, building operators should be available to answer questions about the operating conditions, current preventive maintenance actions, and any known performance problems. Since the building operating staff knows the most about their building, prior to the walk through the building staff should put together a prioritized list of known problems and needed improvements to share with the commissioning provider.

The owner should provide basic building information, including utility data from the previous three years, as well as preventative maintenance records and current service contracts for the provider's review. This information allows the provider to analyze energy use and further understand current O&M practices at the facility. The goal of the walk-through is to confirm that the building is a good candidate for retrocommissioning and to look for indications of problem areas and opportunities that energy bill analysis and phone conversations with building staff cannot provide.

The following items are indicators of retrocommissioning opportunities found during the building walk through – their presence represents potential problems that can be identified and fixed through a retrocommissioning project:

- Systems that simultaneously and excessively heat and cool
- Indication of ineffective use of outside air for free cooling
- Pumps with throttled discharge valves
- Equipment or lighting that is on when it is not needed, especially air handling units that operate for extended periods when the building is unoccupied
- Improper building pressurization - either negative or positive (i.e., doors that are difficult to open or close)

◀ Back to KEY STRATEGIES (p. 35)

- Equipment or piping that is hot or cold when it shouldn't be
- Unusual noises at valves or other mechanical equipment
- Spaces that are over-illuminated

As part of the walk-through, the building owner should inform the commissioning provider of any equipment warranties that are still active. A warranty may become void if the installing contractors and/or manufacturer representatives are not called in to test the equipment and/or implement measures that pertain to the equipment they installed.

Retrocommissioning Scoping Study – When is it needed?

A formal scoping study is often unnecessary if the building is carefully selected as a good candidate; however, for owners who want further assurance before beginning the full retrocommissioning process, a "Scoping Study" may be a good option.

A Retrocommissioning Scoping Study is a brief stand-alone report that describes the possible energy-saving opportunities in a building and recommends an approach for capturing those savings. This report is a low-cost investment to determine if retrocommissioning is appropriate for a particular facility. It also creates a planning mechanism that helps define the objectives, scope, and budget for the in-depth retrocommissioning effort. A scoping study is accomplished in a short time frame (one to three days) and at a minimum consists of a utility bill analysis and a building walk-through. A scoping study helps an owner feel confident that the building is likely to have adequate, low-cost energy-saving opportunities to warrant investing in a full retrocommissioning effort. Some organizations use the scoping study to justify the retrocommissioning project and get buy-in from upper management or outside funding sources. Also, utilities may require a scoping study or preliminary report for buildings to qualify for energy savings incentives.

THE RETROCOMMISSIONING PLAN

If a Scoping Study (see text box above) is not requested, the commissioning provider moves straight into developing a Retrocommissioning Plan. The Retrocommissioning Plan is a document that defines the project's objectives, scope, schedule, and documentation requirements. The plan serves as a guideline for team members to follow throughout the process by providing an outline of the processes and procedures that will be undertaken, a schedule of activities, defined roles and responsibilities of team members, and forms and templates that will be used to document the retrocommissioning activities. The Retrocommissioning Plan should be viewed as a flexible document that is revisited at certain milestones in the project.

◀ Back to KEY STRATEGIES (p. 35)

A good Retrocommissioning Plan should include the following elements:

- General building information and owner 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)
- Description of provider deliverables
- Documentation requests
- Investigation scope and methods
- Implementation Phase requirements
- Project hand-off

The owner's representative should provide input to the provider as the Retrocommissioning Plan is developed. Providing a list of deliverables that the owner expects to result from the retrocommissioning process assists the provider in developing the plan. Possible deliverables include:

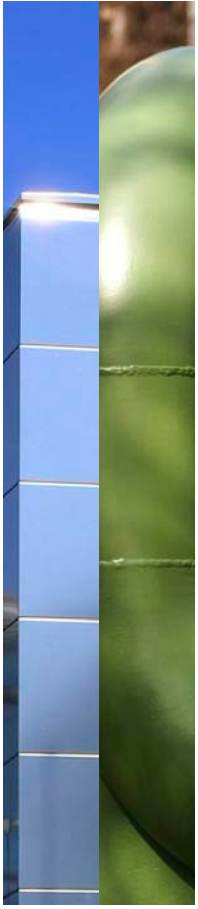
- Retrocommissioning Plan
- Findings Log and energy savings calculations
- Retrocommissioning Investigation Report
- Progress reports and meeting minutes
- List of recommended capital improvements for further investigation
- Implementation Plan
- Retrocommissioning Final Report
- Building staff training materials
- Recommissioning Plan or Ongoing Commissioning Plan

The number and type of deliverables will depend on the scope of the project. The **Retrocommissioning Process Flowchart** on p. 41 identifies typical provider deliverables required by an owner throughout the retrocommissioning process.

◀ Back to KEY STRATEGIES (p. 35)

Chapter 5

◀ Back to KEY STRATEGIES (p. 35)



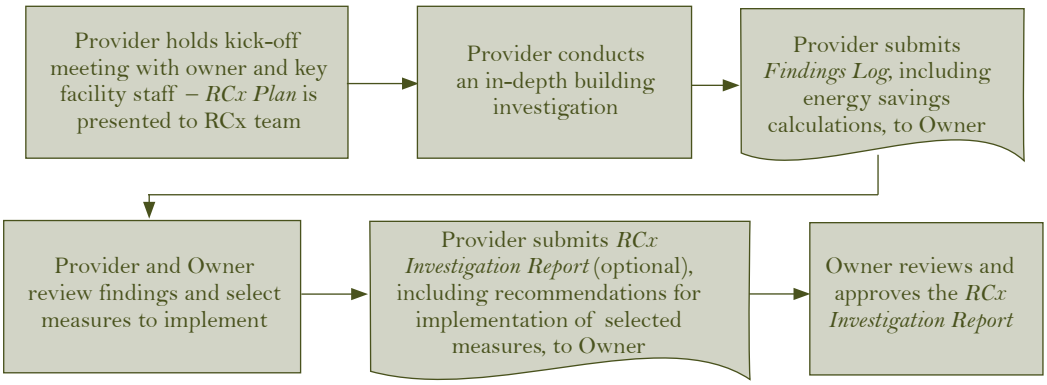
6. INVESTIGATION

The primary goals of the Investigation Phase are to understand how building systems are currently operated and maintained, identify issues and opportunities for improvement, and select the most cost-effective measures for implementation. During investigation, the commissioning provider performs a thorough review of building documents and conducts a methodical analysis of building operations by trending and testing the building systems. The commissioning provider summarizes the results of the investigation analysis in a Findings Log, sometimes called a Master List of Findings. The commissioning provider then presents the results to the owner and helps select measures for implementation.

Highlights:

- Holding the project kick-off meeting
- Information that the provider will need during the Investigation Phase
- Working with incomplete or missing building documentation
- Using diagnostic monitoring and functional testing to uncover the root cause of problems
- Prioritizing and selecting the most cost-effective improvements

Figure 10. Retrocommissioning Process Flowchart: Investigation



◀ Back to KEY STRATEGIES (p. 35)

PROJECT KICK-OFF MEETING

The Investigation Phase typically begins with a project kick-off meeting. A formal project kick-off meeting creates an opportunity to bring critical project team members together to review the Retrocommissioning Plan and discuss the objectives, process, and team roles. Meeting participants may include the owner or owner's representative, facility staff, and any contractors or other professionals who 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.

The commissioning provider and owner should co-lead the kick off meeting. This will demonstrate support from the owner and, at the same time, provide an opportunity for the commissioning provider to establish a collaborative role with other team members. At the kick-off meeting, the owner and provider identify each team member's responsibilities and communicate the owner's expectations for the project. It is important that roles and expectations for each team member are established from the onset.

BUILDING INVESTIGATION

The core of the Investigation Phase is a systematic analysis of the building's performance through direct observation, review of building documents and O&M practices, and monitoring and testing of building systems.

Documentation Review

One of the first actions a provider must undertake during Investigation is a thorough review of building documents. To reduce expenses and maximize the benefit of a retrocommissioning project, in-house facility staff can be assigned to answer questions and help gather necessary building documentation for the provider.

Owner's Operating Requirements

The Owner's Operating Requirements is one of the important documents for the provider to review. If it is incomplete or unavailable, the owner may want to ask the commissioning provider to update or create one. This document addresses the owner's comfort requirements such as space temperature, humidity and outside air fractions, and building schedules. An objective of any retrocommissioning project is to ensure that the building is operating as needed by the owner. Having these requirements clearly documented enables the commissioning provider to be sensitive to building schedules, functions, and processes during the diagnostic activities to avoid disrupting the occupants (**Appendix B** provides a sample Owner's Operating Requirements form, as well as a filled out example).

◀ Back to KEY STRATEGIES (p. 35)

Other Critical Documentation

To the extent possible, the owner should gather the following additional documents for the commissioning provider's review:

- Original design documentation
- Equipment lists, with nameplate information (include age and energy efficiency rating where appropriate)
- Drawings for the building's main energy consuming systems and equipment, including controls, mechanical, and electrical
- Control system documentation, including, point lists, control diagrams and narratives on the sequences of operation
- Operation and maintenance manuals
- Testing, adjusting, and balancing (TAB) reports
- Previous commissioning reports
- Previous energy studies

If the building documentation is out-of-date or incomplete, the owner may want to take advantage of the retrocommissioning project to remedy this. In some cases, the commissioning provider's activities will generate new and useful documentation. The owner can also increase the commissioning provider's scope of work to include improving or developing building documents that ensure the benefits from retrocommissioning last. The owner should, however, bear in mind that preparation of building documentation can be time consuming and may add significantly to the cost of the retrocommissioning project. The final section of this guide, "**Making Retrocommissioning Benefits Last**," contains additional details on building documentation.

How to Proceed if Documentation is Missing

The success of a retrocommissioning project does not hinge on the quality of the building documentation. If, however, building documentation is poor or incomplete, especially for the mechanical and control systems, it can drive up the costs of retrocommissioning. Without essential documentation, the provider will need to spend time gathering and recreating critical information in order to assess system operations.

Facility Staff Interviews

No one knows a building better than the facility staff. After the commissioning provider reviews the building documents, the next step is for the facility staff to help the commissioning provider understand known problems and areas of improvement. Facility staff should consider preparing for discussions with the provider by developing a list of problems and improvements that they want addressed.

◀ Back to KEY STRATEGIES (p. 35)

Chapter 6

DIAGNOSTIC MONITORING AND FUNCTIONAL TESTING

Because retrocommissioning is a method for identifying the root cause of problems and determining the most cost effective solutions, data gathering, testing, and analysis is an integral part of the process. The owner can expect the commissioning provider to perform diagnostic monitoring and functional testing to help uncover the root cause of problems and look for ways to improve existing operating strategies.

Diagnostic Monitoring

Diagnostic monitoring uses the building's energy management control system (ECMS), where these systems exist. For those buildings without an EMCS or adequate points for diagnostics, portable data loggers can be used to gather the data. (See textbox below for a more detailed explanation of the two methods.) Monitoring involves collecting data over time at intervals ranging from one minute to one hour depending on the problem. Variables typically trended include:

- Whole building and end-use energy consumption (such as electrical consumption or demand, gas, steam, or chilled water);
- Operating parameters (such as temperatures, actuator positions, flow rates, and pressures);
- Outdoor temperature and humidity;
- Equipment status and runtimes; and
- Setpoints.

Collecting data this way allows the commissioning provider and facility staff to observe system performance under various modes and operating conditions over time. The next step in the diagnostic monitoring process is to analyze the data. The provider will analyze data and create charts showing hourly, daily, weekly, or monthly trends. Charts can also be used to document how one parameter varies with changes in another. Analyzing this information allows the commissioning provider to characterize system performance and verify whether each system is operating correctly. This information should be shared with the facility staff so they can see how the systems are actually performing. Seeing the data can often lay to rest any guess work or debates about how a system is or should be operating.

Diagnostic Monitoring Methods for Collecting Data

EMCS Trend Logging

Energy management control systems (EMCS) will have different capabilities to do trend logging (trending). These capabilities have a considerable effect on the extent to which trending can be used for diagnostics. Many facilities do a considerable amount of trending, but rarely include in-depth analysis by the building operator.

◀ Back to KEY STRATEGIES (p. 35)

Diagnostic Monitoring Methods for Collecting Data (continued)

Portable Data Logging

Portable data loggers are stand-alone electronic data-gathering devices. Data loggers utilize sensors to collect equipment information at intervals set by the provider for as long as they are left in place. Because data loggers are battery-powered, small, light, and easily installed and removed without disrupting building occupants, they can be an extremely useful diagnostic tools. This is true especially if the EMCS has any limitations on collecting, storing, or presenting data. Many data loggers come with software packages so that data can be downloaded and easily graphed.

Functional Testing

In most cases, it is not possible or cost-effective for the commissioning provider to directly observe all the building's different operating regimes; therefore, the provider performs diagnostic monitoring, coupled with specific functional performance tests. When trend analysis is not enough to determine why a particular problem exists, performing functional tests can help pinpoint the actual cause. Functional tests take the system or piece of equipment through its paces, observing, measuring, and recording its performance in all key operating modes. Functional testing also may be used to help verify whether a particular improvement is needed and cost effective.

Test Protocol

Facility staff can reduce time spent on functional testing by assisting the commissioning team with tasks such as:

- Preparing for tests
- Manipulating the systems to assist the provider in conducting tests
- Putting the systems back to normal following testing

A rigorous test protocol describes exactly how a test will be carried out and includes:

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

◀ Back to KEY STRATEGIES (p. 35)

Prior to performing the most complex functional test, the commissioning provider develops a test protocol. The test protocol clearly describes how the test will be carried out. The owner and provider need to schedule the testing so facility staff are available to handle any necessary preparations, as well as participate in the test. The provider and staff carry out the tests and record all findings on a pre-defined data sheet.

Completing Simple Repairs as the Project Progresses

During the process of Investigation, the need for simple or immediate repairs is often uncovered. While these can be tracked for later action, fixing items as they are discovered is usually the most effective strategy. These adjustments increase the effectiveness of the diagnostic monitoring and testing. Often, a strategic fix (such as a sensor calibration) will support the process of understanding the root causes of operational issues. Planning ahead for this during Investigation allows the owner to set aside a small budget and provides facility staff time to accommodate repair opportunities. Although these repairs may be quick and easy to do, they can sometimes lead to significant energy cost savings and should therefore be recorded as part of the Findings Log.

Investigation Strategies for Short Time Frames

Many retrocommissioning projects are done within a limited time frame; therefore, the diagnostics and testing may only occur during one season. In such cases, the following strategies should be considered:

- Plan to do the investigation during the season where the most problems occur or where the most opportunities lie for saving energy and improving operations. A rigorous utility bill analysis along with building operator recommendations will help determine when the Investigation Phase should occur. This could actually be during the "swing" or "shoulder" season, which occurs in spring or fall when there is low demand for heating or cooling.

- Conduct in-depth interviews with the building operation staff regarding the opposite season from when the investigation occurs. Along with a rigorous review of the building documentation, sequences of operation and energy bills, this may suffice for recommending improvements during the opposite season.

- Consider deferring some testing if there are significant problems in both the cooling and heating season. This can help identify the root cause of a complicated problem occurring in the opposite season from when the investigation takes place. Budget should be allotted for deferred testing in such instances.

◀ Back to KEY STRATEGIES (p. 35)

PRIORITIZE AND SELECT OPERATIONAL IMPROVEMENTS

The process of prioritizing and selecting operational improvements depends on the budget and goals of the owner and is therefore unique to each building. The Investigation Phase results in a list of findings, which are recorded in a Master List of Findings (or Findings Log). In a meeting with the owner, the commissioning provider presents the Findings Log along with recommendations to implement those findings that hold the largest opportunities for improvement and meet the owner's project objectives. Together, the owner and provider select and prioritize the group of findings for implementation and agree on an implementation plan and budget.

Develop a 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. It summarizes every finding from the Investigation Phase, including the "field fixes" made during the course of investigation. At a minimum, the Findings Log should provide a record of measure descriptions, estimated energy savings, cost estimates, simple payback, recommendations for implementation, and status of implementation. A unique identification number should be assigned to each finding to be used as a reference number throughout every retrocommissioning report and document to avoid confusion, especially during implementation.

The owner should participate in the design of the Findings Log to ensure that the necessary information is included. The owner may wish to have an estimated simple payback or return on investment (ROI) for each measure or group of measures reflected in the Findings Log. The Findings Log might also include the following:

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

The owner should request that the savings calculations be provided with the Findings Log. This is especially important for measures that may not be implemented for several months or years. Knowing the original assumptions and calculations saves time and money in updating the costs and paybacks at a later date.

Develop the Investigation Report

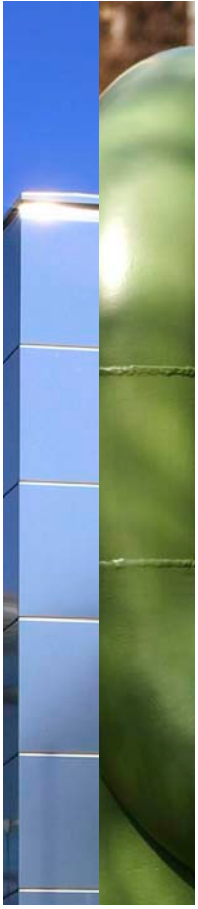
For many owners, the Findings Log will provide sufficient documentation of the Investigation Phase and be an adequate tool to use in making decisions regarding what actions to take during the Implementation Phase. Some owners, however, prefer to have

◀ Back to KEY STRATEGIES (p. 35)

the Findings Log information incorporated into an Investigation Report. In this report, the investigations team provides detailed findings from the site assessment, building documentation review, utility bill analysis, and diagnostic trending and testing. Based on a review of recommendations included in the Findings Log, the owner and provider can reach an agreement on how to proceed with those recommendations. These decisions can be recorded as part of the Investigation Report.

The Findings Log and associated Investigation Report are tools that help owners determine which measures to implement, based on their projected value in terms of energy savings or occupant safety and comfort. The next section – Implementation – discusses the planning process for getting the selected solutions and improvements implemented in the building.

◀ Back to KEY STRATEGIES (p. 35)



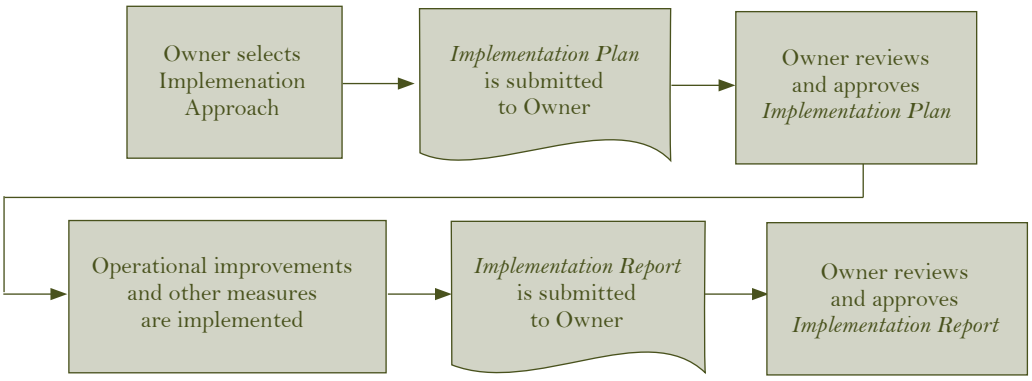
7. IMPLEMENTATION

During Implementation, the operational improvements selected at the end of the Investigation Phase are completed and verified. Depending on the type of project and the resources available to the owner, there are several models for Implementation. This section describes these different approaches and the situations where each is appropriate. This section also discusses the Implementation Plan and Report, important documents, which the owner should request to ensure this phase proceeds effectively.

Highlights:

- Selecting the right implementation approach
- Establishing a reasonable timeline for implementation of chosen measures
- What to expect in the Implementation Plan and Report

Figure 11. Retrocommissioning Process Flowchart: Implementation



◀ Back to KEY STRATEGIES (p. 35)

Chapter 7

SELECTING AN IMPLEMENTATION APPROACH

Once the Investigation Phase is complete, the owner will need to choose an approach for moving forward with Implementation. Implementation usually involves a combination of facility staff, outside contractors, and the commissioning provider, with each doing some portion of the work as appropriate to the building conditions, existing warranties, staff expertise and availability, and budget.

During Implementation, the role of the commissioning provider can be reduced if most of the work is contracted out or undertaken by in-house staff. Retaining the commissioning provider to oversee this phase of the project, however, has a number of advantages. The provider's intimate knowledge of the building systems and needed improvements may ultimately save time and reduce costs, as well as ensure that projected cost effectiveness is achieved. If the commissioning provider stays with the project, it may also be possible to pursue additional retrocommissioning measures that are uncovered during Implementation. In determining the most appropriate strategy, it is helpful to review the following three most common approaches to implementing a retrocommissioning project:

- Turn-key implementation
- Commissioning provider-assisted implementation
- Owner-led implementation

Turn-Key Implementation

In many instances, the commissioning provider can complete the project for the owner by leading implementation activities.

- **Appropriate Projects.** Turn-key implementation is usually applied to projects where the provider is capable of providing the service, and the in-house staff is either not available to implement any of the measures or does not have the necessary skills.

- **Advantages.** Only one contract is held by the owner. Any subcontracts are held and managed by the commissioning provider. This is often the easiest option for the owner, as it reduces the need to coordinate, contract and manage Implementation activities. Also, since the commissioning provider has insight into the building and its system operations, he or she is well-qualified to thoroughly address implementation issues.

Commissioning Provider-Assisted Implementation

Under this approach, the commissioning provider is retained to provide assistance and oversight through implementation, but does not directly complete the majority of the work. The owner holds the contracts with the various firms that will be implementing the retrocommissioning fixes.

◀ Back to KEY STRATEGIES (p. 35)

- **Appropriate Projects.** This approach is ideal when highly skilled, in-house staff are available and can carry out much of the work, as well as when the owner has the time and expertise to manage Implementation.

- **Advantages.** This arrangement takes advantage of in-house capabilities while simultaneously leveraging the expertise of the commissioning provider to oversee the coordination and outcome of the work. Working with a commissioning provider in Implementation also can build skills among facility staff, so that they are better able to maintain performance of systems over time. In this role, the commissioning provider can help the owner define the scope of work for in-house staff and contractors, coordinate scheduled work, and verify that the results meet expectations.

Owner-Led Implementation

The owner also can choose to take the results and recommendations from the Investigation Phase and proceed to the Implementation Phase without further assistance from the commissioning provider.

- **Appropriate Projects.** 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 retrocommissioning measures. *Note that, even in this case, the commissioning provider should still conduct the tasks outlined in the Hand-Off Phase section that follows.*

- **Advantages.** This approach takes advantage of existing in-house facility staff expertise and established service contractor relationships. In some cases, this is the goal of owners who adopt retrocommissioning as a "business-as-usual" practice. They may start projects with very little retrocommissioning expertise among their facility staff and, over the course of several retrocommissioning projects, seek to build the ability and expertise in-house to manage their own projects. This approach does, however, require significant commitment on the part of the owner.

SETTING A TIMETABLE

Some owners adopt a staged implementation plan to accommodate budgeting constraints, but other owners may implement all measures in one project. While each situation is unique, following up on all or most of the measures immediately after the Investigation Phase has several compelling advantages. Project momentum, consistent staff involvement, and maximum cost savings are all substantial reasons to keep the project going right into Implementation.

◀ Back to KEY STRATEGIES (p. 35)

THE IMPLEMENTATION PLAN

Once the owner has selected measures in consultation with the commissioning provider and has determined the most appropriate approach to managing the Implementation Phase, the provider develops an Implementation Plan. The Implementation Plan organizes and defines the work needed to implement the measures selected by the owner. It also describes the required results, how to get them, and how to verify that the objectives have been met. The Implementation Plan can include 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 may also recommend methods for verifying the performance of the measures after implementation.

The Implementation Plan takes on different forms and is used in different ways depending on the approach selected to manage the work. It can be a guideline for building staff to make the repairs and improvements, or it can be 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. (**Appendix C** includes a sample Retrocommissioning Implementation Plan.)

IMPLEMENTATION VERIFICATION AND REPORTING

As measures are implemented and the project moves forward, it is critical to document and verify the results. This is an important part of the Implementation Phase and has value beyond assuring the correct completion of work, since it also establishes a new baseline for performance.

As measures are completed, it is important to retest the equipment or systems to ensure that the improvements are working as expected. Retesting can be done with the same diagnostic testing methods used in the Investigation Phase, such as EMCS trending, data logging, functional testing, simple observation, or a combination of these methods. When retesting, post-implementation data are compared to the original baseline data to confirm that the combination of improvements are integrated and have the desired effect on the building.

The commissioning provider can use the verification data to update the energy savings estimates as needed. Verification data can also be used to establish a new baseline for the performance of each of the treated building systems. The new baseline can 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.

The Implementation Report documents each measure with a description, resolution status, resolution description, and any future recommended actions. (**Appendix D** provides a sample Retrocommissioning Implementation Report.)

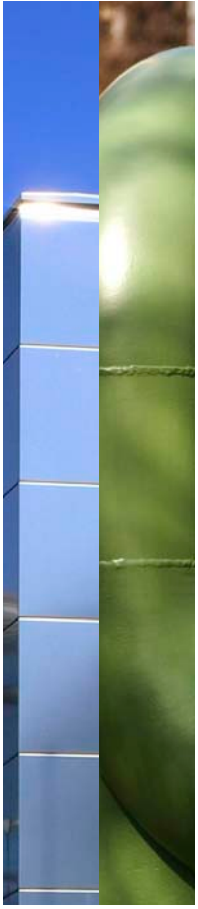
◀ Back to KEY STRATEGIES (p. 35)

Once all the improvements are completed and verified a new EPA energy performance rating should be generated in the *Portfolio Manager* online tool. Since the score is based on the past year of utility data, retrocommissioning energy savings will be reflected in the EPA energy performance rating over time. This will provide a new baseline score against which each following year's building performance can be matched.

◀ Back to KEY STRATEGIES (p. 35)

Chapter 7

◀ Back to KEY STRATEGIES (p. 35)



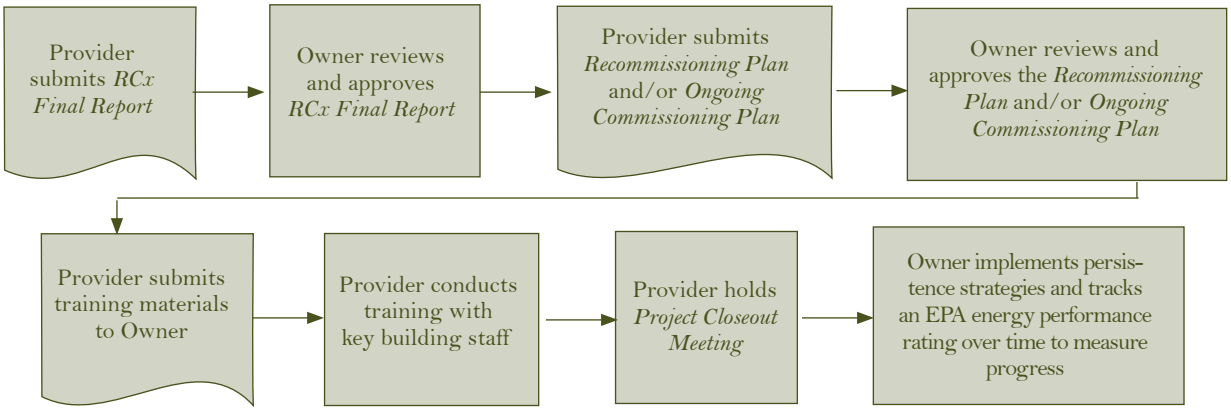
8. PROJECT HAND-OFF

Project Hand-Off is the final phase of a retrocommissioning project. In this Phase, the commissioning provider develops reports and other significant documents that summarize the project. These reports are useful in maintaining the results that retrocommissioning achieved, as well as in providing the basis for facility staff training. During this Phase, the commissioning provider also assists the owner in determining the best strategies for keeping the new improvements functioning efficiently over time. Without these *persistence* strategies (discussed in the final section of this guide), retrocommissioning measures sometimes can be circumvented, changed, or ignored by facility staff. With an effective Hand-Off Phase, the measures will not only continue to deliver cost savings and contribute to the improved quality of the building, but the project can also be the foundation for continued operational improvement.

Highlights

- What to expect in the Final Report
- Importance of facility staff training
- Getting recommendations to ensure that retrocommissioning improvements persist
- The project Close-Out meeting

Figure 12. Retrocommissioning Process Flowchart: Persistence and Hand-Off



◀ Back to KEY STRATEGIES (p. 35)

THE FINAL REPORT

A key responsibility of the commissioning provider during the Hand-Off Phase is to develop the retrocommissioning Final Report. The Final Report brings together important information from other retrocommissioning deliverables into a single document. As a comprehensive record of the project, it should become a part of the on-site resources for facility staff. The specific contents of the Final Report will vary according to owner needs, but may include the following:

- Executive Summary
- Owner's Operating Requirements
- The Findings Log with descriptions of the implemented measures
- Updated savings estimates and actual improvement costs
- The EMCS trending plan and data logger diagnostic/monitoring plan
- All completed functional tests and results
- Recommended frequency for recommissioning
- Complete documentation of revised or new control sequences (or where this can be found)
- Recommendations for maintaining the new improvements
- Training Summary including training materials
- A list of capital improvements recommended for further investigation

FACILITY STAFF TRAINING

To ensure that the benefits of retrocommissioning are maintained over the long-term, building operators and managers must have the right knowledge and skills. In addition to involving facility staff during the course of the project, it is important for the owner to request that the commissioning provider develop and conduct additional training for facility staff at the end of the project. This training is particularly important for those staff members who were not part of the day-to-day retrocommissioning activities. Such training provides an opportunity to address how staff can maintain the retrocommissioning improvements, as well as any aspects of the building's typical operations and maintenance practices that are of concern in maintaining a high level of system performance. A training session typically involves a classroom workshop with some hands-on demonstrations on the building equipment. Owners should consider videotaping the training session for future reference and as resource for training new facility staff.

RECOMMENDED PERSISTENCE STRATEGIES

An owner should consider having the retrocommissioning provider recommend persistence strategies to help ensure that the benefits of the retrocommissioning project continue beyond the life of the project itself. These strategies, discussed in detail in the next section, include the following:

◀ Back to KEY STRATEGIES (p. 35)

- Developing policies and procedures for updating building documentation
- Providing ongoing training for building staff
- Ensuring efficient operating performance
- Tracking energy and system performance
- Periodically recommissioning the building, paying close attention that the original retrocommissioning improvements are still producing benefits
- Instituting a plan of ongoing commissioning

PROJECT CLOSE-OUT MEETING

The owner should hold a project close-out meeting and work with the commissioning provider to develop the agenda and lead the meeting. At the close-out meeting, the commissioning provider presents the Final Report to the owner and project staff and answers questions from the staff and management about the project process, findings, and deliverables. Any remaining issues and next steps can be included in the meeting discussion. It is helpful to structure this meeting as an opportunity to not only review the project, but also to celebrate its success and discuss the applicability of the process in regard to other buildings in the owner's portfolio.

The owner should expect the Final Report to include recommendations for strategies to ensure lasting benefits from retrocommissioning. As part of the Hand-Off Phase, the owner and commissioning provider should decide which of the recommended strategies to implement. The next section describes several persistence strategies.

Recommended Hand-off Training Topics

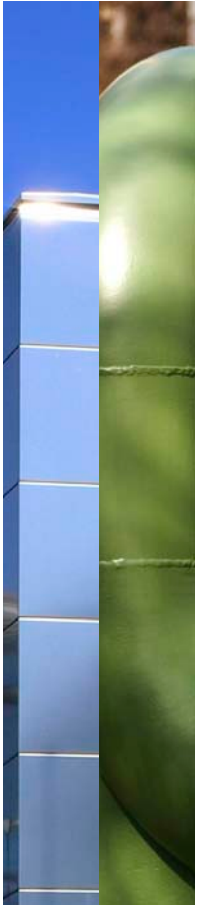
- Energy usage analysis
- Energy benchmarking
- Operating schedules & Owner's Operating Requirements
- Investigation process & methods used to identify problems and deficiencies
- Master List of Findings
- Measures that were implemented and by whom
- Expected performance improvements from these measures (show before and after trends if applicable)
- O&M requirements 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.

◀ Back to KEY STRATEGIES (p. 35)

Chapter 8

◀ Back to KEY STRATEGIES (p. 35)



9. MAKING RETROCOMMISSIONING BENEFITS LAST – STRATEGIES FOR ENSURING PERSISTENCE

There are many things that can be done to ensure that the benefits from retrocommissioning persist. Particularly for controls improvements, it is important to use persistence strategies to reduce the chance that retrocommissioning measures are changed or modified in ways that reduce their benefits.. This section provides information on activities that an owner might want to consider to ensure that their investment in retrocommissioning continues to pay off in the future.

Highlights:

- Developing building documentation
- Planning for staff training
- Maintaining efficient operating performance
- Performance tracking
- Recommissioning and ongoing commissioning

◀ Back to KEY STRATEGIES (p. 35)

BUILDING DOCUMENTATION

For existing buildings that do not have complete or up-to-date documentation, the retrocommissioning project offers a useful opportunity to update or create these resources. These documents supply building operators as well as HVAC, controls, or maintenance service contractors, with the information they need to operate and maintain systems and equipment, and troubleshoot problems so the retrocommissioning measures continue to perform as expected.

Essential documents that should be updated or created as part of the retrocommissioning project include:

- Equipment Lists
- O&M Manuals
- Control System Documents (points lists, sequences of operations, system diagrams)

Equipment Lists

Typically, the equipment lists contain the following information for each piece of equipment:

- Unique equipment identification number and name, such as AHU-2
- Nameplate information, including model and serial numbers
- 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. In order for the staff to use them effectively, the information they contain must be well-organized. To increase usability, an index and table of contents should be included. It may also be helpful to organize the manuals by system, rather than by specification. O&M Manuals typically include:

- Installing contractor contact information
- Product data
- Test data
- Performance curves (pumps, fans, chillers, etc.)
- Installation instructions
- Start-up procedures
- Sequences of Operations
- Preventive maintenance requirements
- Parts lists
- Troubleshooting procedures specific to the equipment design and application
- Equipment submittals
- Design documents
- Control strategies

◀ Back to KEY STRATEGIES (p. 35)

- Copies of commissioning tests, if applicable
- Copy of TAB report
- Warranty information

If a building already has good, up-to-date O&M Manuals, they may only need to be modified to include any changes to equipment or operations that are made as part of the retrocommissioning project. If 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 trend logging purposes, it is helpful to have a complete Points List that includes all the physical input and output points in the control system. Any changes made to the Point Lists as part of the retrocommissioning process should be recorded promptly. The Points List should include:

- Point name (adhering to a consistent and clear naming convention)
- Point type
- Sensor or actuator type and accuracy limits
- Name and type of the associated component
- Panel in which it is located
- Alarm limits

Sequences of Operation

Sequences of Operation inform the building staff about how the control system should operate the building. In many cases, the original sequences were programmed into the EMCS but never put in writing, or the existing written sequences lack sufficient detail to help building staff understand how the controls are integrated within and among systems.

At minimum, any changes that were made to the control sequences as a result of retrocommissioning should be carefully documented, along with the reasons for the changes. Improvements are more likely to persist when operators understand the rationale for the changes and agree with their implementation. Also, it may be worthwhile to consider rewriting any control sequences that were not affected by the retrocommissioning project, but are found to be incorrectly or poorly documented.

System Diagrams

System Diagrams, which are sometimes called one-line diagrams, enable the user to see the entire process of heating, cooling, and ventilation of spaces and visualize potential interactions. They depict an entire system in schematic format.

These one-line diagrams are typically produced during the initial part of the investigation process to help the commissioning team better understand how the various systems are laid out and

◀ Back to KEY STRATEGIES (p. 35)

whether the current building documentation is correct. Also, a simple system diagram goes a long way in clarifying the intended operation of the entire system and helps to identify possible errors that occurred during the construction of the system. Once completed, the system diagrams can be incorporated into the control system operator workstation.

As an example, 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.

Enhanced Documentation

An owner may want to take advantage of the retrocommissioning process to develop building systems documentation not previously compiled. The Systems Manual can be thought of as an umbrella document that includes the retrocommissioning Final Report, as well as most of the building's critical O&M documentation or, at minimum, describes how O&M documents are cataloged and where they are located. Also, the Systems Manual may include new materials emphasizing how systems and equipment interface. While a Systems Manual is not a commonly produced deliverable for a retrocommissioning project due to cost considerations, it is a worthwhile effort, especially for complex systems or in cases where O&M staff turnover is common. An owner may specify the Systems Manual in the commissioning provider's scope of work or request that it be developed collaboratively between the owner and the provider. The most effective scope of the Systems Manual is typically determined on a project-by-project basis.

A Systems Manual often includes:

- Master list of building documentation and locations
- Owner's Operating Requirements
- Retrocommissioning Plan
- Retrocommissioning Final Report
- O&M Plan (includes recordkeeping procedures)
- Sequences of operation for all control systems
- System diagrams
- List of monitoring and control points
- List of control system alarms
- Trending capabilities

For more detailed information about the components of a Systems Manual, consult ASHRAE Guideline 0, The Commissioning Process, Informative Annex O. This document is available for purchase on the ASHRAE website (**www.ashrae.org**).

◀ Back to KEY STRATEGIES (p. 35)

BUILDING STAFF TRAINING

As discussed in the Hand-Off section, facility staff training is critical to maintaining the benefits of retrocommissioning. 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. Videotaped trainings, developed during the Hand-Off Phase of the retrocommissioning process, are especially valuable for new staff.

Owners may wish to consider a broader range of training activities, in addition to those provided at the end of the retrocommissioning process. Perhaps the most common training opportunity lies in understanding and using the trending and alarming functions of the control system. The wide gap between the capabilities of these complex systems and the ability of building operators to fully utilize them can lead to missed opportunities in both the early identification of building problems and significant energy savings. For example, trends and alarms can be set in the control system, but unless the staff responsible for the energy management control system are trained on how to retrieve and analyze the data and review alarm logs, the owner will not get the most out of the system. Many control vendors offer a range of training opportunities from introductory to advanced sessions. Training pays for itself quickly when operators know how to use all the capabilities of the system.

Through high-quality training, facility staff can increase their knowledge and expand their ability to identify and address improvement measures in their buildings. One option for training that is available in many locations across the country is the Building Operator Certification (BOC) course series. This series is designed specifically for building operators to improve their ability to operate and maintain comfortable, energy-efficient facilities. The courses are offered at two skill levels. Both address multiple topics including electrical, HVAC, and lighting systems, indoor air quality, environmental health and safety, and energy conservation. More information on locations, schedules, and descriptions is available on the BOC website at: **www.theboc.info**. Other training courses are commonly offered by utility energy centers, training organizations, and equipment manufacturers.

◀ Back to KEY STRATEGIES (p. 35)

Chapter 9

MAINTAINING EFFICIENT OPERATING PERFORMANCE

The biggest challenge for facility staff is to redefine their preventive maintenance program to include activities that maintain the retrocommissioning operational improvements. Operational activities need to be incorporated to ensure long-term energy efficiency and reliability. Owners can enhance preventive maintenance goals by incorporating procedures that promote efficient operation.

A typical preventive maintenance plan consists of a checklist of maintenance tasks and a schedule for performing them. It can be extensive and is often computerized. The checklists are kept for each piece of equipment and are updated after maintenance tasks are performed. Incorporating operations into the current maintenance plan requires 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. Incorporating operational activities into the preventive maintenance plan encourages building operators to continuously ask questions such as:

- Have occupancy patterns or space layouts changed?
- Has the tenant added or removed loads from the space?
- Have temporary occupancy schedules been returned to original settings?
- Have altered equipment schedules or lockouts been returned to original settings?
- Is equipment short-cycling?
- 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?
- Are the building's sequences of operation performing as intended?
- Are discretionary systems, such as lighting or computers, being turned off during unoccupied periods?

To facilitate activities that address operations, the owner can require an Ongoing Commissioning Plan be developed at the end of the retrocommissioning project. This plan focuses on strategic operation and maintenance activities that support the retrocommissioning improvements. The Ongoing Commissioning Plan is discussed at the end of this section.

It may seem like expanding the preventive maintenance plan would significantly increase the workload of building staff. Performing these tasks on a regular basis, however, should save staff time in the long run as preventive operation activities help to reduce occupant comfort complaints and equipment malfunction. More time spent on preventive operations generally means that less time is spent "fighting fires" and troubleshooting problems. Also, the efficiency of the systems that was achieved during retrocommissioning may decline unless explicit strategies are put into place to maintain and monitor the improvements.

◀ Back to KEY STRATEGIES (p. 35)

PERFORMANCE TRACKING

Performance tracking 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 vital for building operators to know when systems aren't functioning properly. Unfortunately, a formal process for data gathering and analysis is not typically established at a facility.

There are three important strategies for tracking building performance:

- Benchmarking
- Utility billing analysis
- Trend analysis

These activities are commonly performed as part of the Planning and Investigation Phases of a retrocommissioning project and present an opportunity for the building staff to learn and determine ways to incorporate them into their preventive maintenance plan. In this way, these strategies are performed on a regular basis, which actively helps ensure that the recommissioning benefits last.

Benchmarking

Benchmarking a building allows an owner to compare the building's current performance to past baseline levels of performance, as well as to the performance of similar buildings. This is a way for owners to assess how their building is doing and determine whether there is potential for improvement. In the case of retrocommissioning, benchmarking should be done before the start of the project to set a baseline. When the project is complete and about six to 12 months of utility bills are available, the building can be benchmarked again to see the effects of the retrocommissioning process. As discussed in earlier sections, owners may wish to take advantage of the EPA's *Portfolio Manager* online tool.

Utility Bill Analysis

Utility tracking records a building's energy use over time and helps staff understand the building's energy consumption patterns. By tracking energy data over time, facility managers and building operators can detect and investigate high energy use.

Trend Analysis

Trend logging through the energy management control system is important for observing the performance of systems under various modes and operating conditions over time. Trending is typically the central strategy for ensuring that the

◀ Back to KEY STRATEGIES (p. 35)

implemented retrocommissioning measures persist. Data collection, however, is just the first step. Facility staff also should be trained to analyze and interpret the data. To support this, important metrics should be defined during retrocommissioning along with evaluation methods.

The commissioning provider's scope of work can include setting up "smart alarms" in the DDC system – alarms that flag problems by looking at several variables at one time, or comparing variables to limits that depend on the operating mode. Facility staff should be trained to recognize what alarm conditions signify, how to respond to these alarms when they are triggered, and how to set up their own alarms.

The DDC system does not, however, provide the whole story. Building operators should check each piece of equipment regularly and note any changes that may not be picked up by trend logging. This information can then be combined with DDC system data for a more complete picture.

RECOMMISSIONING

The need for recommissioning following the initial retrocommissioning project depends on several things: changes in the facility's use, quality and schedule of preventive maintenance activities, and the frequency of operational problems. In terms of both cost and process, it is most effective to develop the recommissioning timeline as a part of the retrocommissioning project's scope of work and to factor estimated recommissioning costs into future budget cycles.

The recommissioning process is similar to retrocommissioning, although it is generally less expensive since it builds on the information gathered and produced as part of the retrocommissioning project. As in retrocommissioning, systems are monitored, tested, and inspected and any issues are recorded in a new Findings Log for potential implementation. If a Recommissioning Plan was drafted by the commissioning provider during Hand-Off, this process should be straightforward. At completion, the building documents are updated to reflect any changes in building systems and functions.

Time to Recommission?

Positive answers to two or more of the following questions indicate 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 the building staff aware of problems, but lacks 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)?

◀ Back to KEY STRATEGIES (p. 35)

ONGOING COMMISSIONING PLAN

An Ongoing Commissioning Plan can be developed by the commissioning provider after the Implementation Phase and can be a primary deliverable for the Hand-off Phase. This is a more comprehensive plan than the Recommissioning Plan in that it provides building staff with detailed instructions on performing strategic operation and maintenance tasks that help retain the retrocommissioning benefits. Where as recommissioning is often performed every three to five years and provides a "snapshot" of how the building is operating at a given time, ongoing commissioning is more continuous and dynamic by nature in that it encompasses all of the performance tracking strategies discussed above.

◀ Back to KEY STRATEGIES (p. 35)

Chapter 9

◀ Back to KEY STRATEGIES (p. 35)

10. RESOURCES

This page contains information on additional sources of information and other reference materials that the owner may find useful in the retrocommissioning process.

Key Sources of Information

ENERGY STAR® www.energystar.gov
The U.S. EPA-sponsored program to help people and businesses achieve superior energy efficiency. The website contains advice on reducing energy use and energy benchmarking tools.

California Commissioning Collaborative www.cacx.org
The California Commissioning Collaborative (CCC) website contains case studies, sample documents, a provider list, tips on selecting a provider, and a searchable library of commissioning documents. Sample documents and templates currently available on the website include:

- Retrocommissioning Plan
- Design Intent
- Systems Manual
- Sequence of Operations

Portland Energy Conservation, Inc. (PECI) www.peci.org
PECI's Resource Library contains several commissioning resources, including the Model Plan and Guide Specifications, Functional Testing Guide, Control Systems Design Guide, O&M Best Practices Series, and the Proceedings of the National Conference on Building Commissioning.

American Council for an Energy Efficient Economy (ACEEE)
The ACEEE website includes a section on building performance with links to technical and programmatic resources. **www.aceee.org**

American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE)
The ASHRAE website provides commissioning guidelines, links, research, tools, and recommendations. **www.ashrae.org**

Building Commissioning Association (BCA)
An organization of commissioning professionals, BCA offers, via its website, publications, templates, training announcements, and an on-line discussion forum. **www.bcxa.org**

Building Operator Certification (BOC)
The BOC is a nationally recognized training and certification program for building operators, designed specifically to help them improve their ability to operate and maintain comfortable, efficient facilities. **www.theboc.info/ca**

◀ Back to KEY STRATEGIES (p. 35)

Energy Design Resources
This website offers a variety of energy design tools and features the Cx Assistant, a web-based tool that provides project specific building commissioning information, helps users evaluate probable costs and appropriate scope, and provides access to sample commissioning specifications. **www.energydesignresources.com**

Federal Energy Management Program (FEMP)
FEMP's website offers information, tools, and recommendations on a variety of energy topics, including equipment procurement, retrofits, operations and maintenance, and utility management. **www.eere.energy.gov/femp/operations_maintenance/**

Lawrence Berkeley National Laboratory (LBNL)
LBNL's Building Technologies Department performs research and development leading to better energy technologies and reduction of adverse energy-related environmental impacts. Their High Performance Commercial Building Systems program has an emphasis on integrated commissioning and diagnostics, and has many publications related to commissioning. **www.eetd.lbl.gov**

National Environmental Balancing Bureau (NEBB)
NEBB helps architects, engineers, building owners and contractors. They establish and maintain industry standards, procedures, and specifications for work in its various related disciplines. **www.nebb.org**

Rebuild America
A program of the U.S. Department of Energy focused on community-based solutions to reducing energy use in existing buildings. **www.rebuildamerica.gov**

U.S. Green Building Council (USGBC)
Website offers information on the LEED® Green Building Rating System. **www.usgbc.org**

◀ Back to KEY STRATEGIES (p. 35)

11. REFERENCES

California Energy Commission. *California Commissioning Guide: Existing Buildings* (2006). Prepared by Portland Energy Conservation, Inc. (PECI).

Dunn, Wayne, Wade Berner, and David Venters. "Rolling the Dice: Using Risk Tolerance to Define Commissioning Scope," *Proceedings of the National Conference on Building Commissioning* (San Francisco, CA, April 19 – 21, 2006).

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

Gregerson, J. "Cost Effectiveness of Commissioning 44 Existing Buildings," *Proceedings of the National Conference on Building Commissioning* (Huntington Beach, CA, April 28 – 30, 1997).

Haasl, Tudi, 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.* World Energy Engineering Congress. (2004).

Jewell, Mark. RealWinWin, Inc. "Understanding the Value of Commissioning in Income-Producing Office Buildings," *Proceedings of the National Conference on Building Commissioning* (Palm Springs, CA, May 20 – 22, 2003).

Mills, E., H. Friedman, T. Powell, N. Bourassa, D. Claridge, T. Haasl, and M.A. Piette. 2004. "The Cost-Effectiveness of Commercial-Buildings Commissioning," Lawrence Berkeley National Laboratory. http: //eetd.lbl.gov/EMills/PUBS/Cx-Costs-Benefits.html

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).

Oregon Department of Energy. Information gathered from the Building Commissioning Savings summary found on the Oregon Department of Energy's website at http://www.oregon.gov/ENERGY/CONS/BUS/comm/commsave.shtml

Oregon Department of Energy. *Retrocommissioning Handbook for Facility Managers* (2001). Prepared by Portland Energy Conservation, Inc. (PECI).

◀ Back to KEY STRATEGIES (p. 35)

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

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

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

U.S. Environmental Protection Agency. *2003-2008 EPA Strategic Plan: Direction for the Future* (September 30, 2004).

U.S. Environmental Protection Agency. *Operations and Maintenance Assessments: A Best Practice for Energy-Efficient Building Operation* (1999). Prepared by Portland Energy Conservation, Inc. (PECI).

U.S. Environmental Protection Agency *O&M Best Practices Series* (1999).Prepared by Portland Energy Conservation, Inc. (PECI) and U.S. Department of Energy.

Williams, Scott D. "Owner's Strategies for In-House Commissioning," *Proceedings of National Conference on Building Commissioning* (New York, NY, May 4 – 6, 2003).

◀ Back to KEY STRATEGIES (p. 35)

APPENDIX

The following documents provide examples of tools and templates that can be used to facilitate the retrocommissioning process, from preliminary planning through implementation. These and other resources are available online as part of the **California Commissioning Collaborative's Retrocommissioning Toolkit** (**http://www.cacx.org/resources/rcxtools**).

APPENDIX A: List of Preferred Building Characteristics for Retrocommissioning

APPENDIX B: Owner's Operating Requirements

APPENDIX C: Retrocommissioning Implementation Plan

APPENDIX D: Retrocommissioning Implementation Report

APPENDIX E: Request for Proposal Checklist

APPENDIX F: Linking Energy Savings Performance Contracts and Retrocommissioning

◀ Back to KEY STRATEGIES (p. 35)

APPENDIX A - LIST OF PREFERRED BUILDING CHARACTERISTICS FOR RETROCOMMISSIONING

The following briefly discusses some important building characteristics that should be considered during the planning phase of a retrocommissioning project when a building owner and commissioning provider are determining whether a building is an appropriate retrocommissioning candidate. Most existing buildings are candidates for retrocommissioning however some buildings are better candidates because they have characteristics that can help reduce project costs. Using the following preferred characteristics list as a screen during the planning phase can help to determine what may bolster or create barriers to the cost effectiveness of a project. A checklist that summarizes the characteristics is also included. Using the checklist can assist in identifying these important characteristics during the scoping and budgeting process.

Note: For the purpose of this document, retrocommissioning is a process that seeks to find primarily operational improvements that can improve the energy and comfort performance of modernly equipped, medium to large buildings. Retrocommissioning for small buildings or buildings in need of major equipment upgrades is beyond the scope of this document, although some of these characteristics may also apply.

1. Mechanical equipment age and condition

When a retrocommissioning project is defined as a set of activities to improve building performance through mainly operational improvements, the cost-effectiveness of a project partly depends on the age of the energy-using equipment, systems, and controls. Buildings with equipment that is broken or in need of major upgrades generally do not make good candidates for this type of retrocommissioning. Equipment and systems that are less than 12 years old or are several years from the end of their useful life and are well maintained are ideal. However, the age of equipment is less of a problem as long as the equipment has been well maintained.

2. Financial Considerations

The owner's financial criteria such as the required simple payback time and the cost limits that determine when to obtain funds from the capital budget vs. the operating budget should be gathered early on in the planning phase of the project. These criteria, along with budget cycle information, can help the commissioning provider and owner determine how to prioritize the work during the retrocommissioning process and how to develop implementation strategies that can fit with in the financial criteria. Also, If the building is located where there are tax incentives or rebates available (some utilities give incentives for retrocommissioning and retrofits) these can help off-set some of the costs and help reduce payback times, allowing more expensive improvements to fit into the owner's financial requirements.

◀ Back to KEY STRATEGIES (p. 35)

3. Building staff participation

The cost effectiveness of a project may be greatly increased when the building staff is given the time and is skilled enough to perform some of the retrocommissioning tasks throughout the project. Retrocommissioning costs may be reduced when an owner is willing to engage the facility team in getting the maintenance items and simple repairs (coil cleaning, filter changes, belt tightening, broken linkages and damper blades) completed before the retrocommissioning investigation. These activities allow the commissioning provider to proceed efficiently through the system investigation without the process getting bogged down with simple maintenance and repairs issues. Also, building staff can minimize costs by helping set up the trend logs, setting and removing data loggers and implementing some of the less complicated measures. Staff involvement on this level reduces the need to hire outside contractors. It is ideal if the building owner or manager assigns a senior level building technician to work with the retrocommissioning provider. At a minimum, it is important for building staff to be available to provide the commissioning provider with as much information about the building's operating strategies, maintenance procedures, and perceived problems as possible.

4. Buildings with energy management control systems (EMCS)

Buildings with computerized energy management control systems (EMCS) are preferable candidates to those with purely pneumatic systems. This is due to two main factors: an EMCS can be used as a data acquisition tool during retrocommissioning where as a purely pneumatic system cannot, and pneumatic controls tend to drift out of calibration much more frequently than electronic based controls, so that energy saving may not be long lasting in buildings without EMCS. However, the owner and or provider should carefully examine the level of robustness of the EMCS in order to understand what it can and can't do. More robust systems are able to trend and store large amounts of data at short frequencies (2 minutes or less) for long periods of time without slowing down the normal control functions of the system. Some of the most robust systems are also web based. A web based system allows the commissioning provider to look at building data from an internet connection at any time. Without adequate trending and data storage capability, the commissioning provider will need to use more portable data loggers and handheld test equipment than is typically used, which can add time and expense to the project.

5. Available and up-to-date building documentation

When scoping a project, it is important to understand what building documentation is available. Clear, complete, up-to-date documentation expedites the investigation phase of a project. Buildings that lack good documentation, especially in regards to the mechanical and control systems, can drive costs up if the commissioning provider has to spend time gathering and recreating critical information in order to assess system operation. An example list of important building documentation is included in the Preferred Building Characteristics Checklist below.

◀ Back to KEY STRATEGIES (p. 35)

6. Owner Support and the In-house Champion

There is probably not a more important combination that will lead to a project's success than to have an involved, supportive owner along with a technically savvy in-house champion. However, owners are often absent or distracted by other important tasks, making it difficult to gauge their level of interest in a retrocommissioning project. Furthermore, the building staff may lack the preferred technical training needed to be an active hands-on partner in the retrocommissioning process. Therefore, a critical ingredient for a project's success is an in-house champion such as an energy manager, facility manager or property manager, that is willing to work as a facilitator to get what needs to be done accomplished in a timely manner. In any case, looking at an owner's investment history in energy efficiency and sound O&M practices as an indicator of a progressive management philosophy and commitment to improving building operations allows the commissioning provider to more easily judge the seriousness of the owner to support the retrocommissioning project.

7. Future Building Projects and Changes

When developing a retrocommissioning project scope, it is wise for the building owner to explain to the commissioning provider what the future plans are for the building. For example, if an owner is considering doing some retrofit projects or major tenant improvements in the near future (within the next year or two) it may be advantageous to wait for these activities to occur before going forward with a full retrocommissioning project. On the other hand, depending on what the improvements are, the retrocommissioning project can be designed to have a commissioning component to ensure that new installations are specified, installed and operated as intended, and integrated completely with the existing systems in the building. Further, it may be highly beneficial to retrocommission some of the systems before a major retrofit in cases where reducing loads may lead to downsizing equipment included in the retrofit. Another consideration is how the operations and maintenance will be accomplished in the future. How this is done can affect the persistence of the benefits realized as a result of the project. Questions about plans for outsourcing the maintenance and staff turnover can affect the training and documentation scope for the project.

◀ Back to KEY STRATEGIES (p. 35)

Preferred Building Characteristics Checklist

Mechanical Equipment Age and Condition

- ☐ Building does not rely on a majority of major systems or equipment that is in disrepair or in need of major upgrades.
- ☐ The majority of building equipment and systems are less than 12 years old or are several years from the end of their useful life (older equipment that is well maintained can last well beyond the typical replacement life cycle).
- ☐ Equipment and systems are well maintained.
- ☐ There is no evidence of excessive deferred electrical and mechanical maintenance issues.

Financial Considerations

- ☐ Information is available regarding owner's investment criteria such as simple payback requirements and use of capital budget vs. operating budget.
- ☐ The building may qualify for financial incentives through local programs or tax incentives

Building Staff Participation

- ☐ Building staff is available to provide information about the building's operating strategies, maintenance procedures, and perceived problems.
- ☐ Management is willing to direct building staff to perform scheduled maintenance items and simple repairs prior to the retrocommissioning investigation.
- ☐ Building staff is skilled enough to perform some of the retrocommissioning tasks throughout the project.
- ☐ Management is willing to allocate staff time to performing some of the retrocommissioning tasks throughout the project (i.e. help set up the trend logs, set and remove data loggers and implement some of the less complicated measures).

Building Controls

- ☐ Building has computerized energy management control systems (EMCS).
- ☐ EMCS is robust enough to use as a data acquisition tool during retrocommissioning:
  - EMCS is able to trend and store large amounts of data at short frequencies (2 minutes or less) for long periods of time without slowing down the normal control functions of the system.
  - EMCS is web-based, allowing the commissioning provider to look at building data in real time from an internet connection at any time.

◀ Back to KEY STRATEGIES (p. 35)

- Trend data files are conducive to spreadsheet analysis (multiple points possible in each .csv file export, limited missing or bad data included).

Available and Up-to-Date Building Documentation

Building has clear, complete, and up-to-date documentation of the following items:

- ☐ As built mechanical and electrical drawings including piping and riser diagrams
- ☐ An equipment list with nameplate information and dates of installation
- ☐ As built control system documentation
  - Points list
  - Sequences of operation
  - User's manual
  - Control drawings with as-built sensor locations
- ☐ Testing, Adjusting and Balancing reports
- ☐ Operation and maintenance manuals
- ☐ Pump and fan curves
- ☐ Copy of current service contracts
- ☐ Equipment warranties still in effect

Owner Support and the In-House Champion

- ☐ Building owner is involved and supportive of the retrocommissioning process.
- ☐ The retrocommissioning project has a technically savvy in-house champion that will facilitate the process.
- ☐ Owner has an investment history in energy efficiency and sound O&M practices that indicates a progressive management philosophy and commitment to improving building operations.

Future Building Projects and Changes

- ☐ No major retrofit projects or major tenant improvements are planned within the next 1-2 years.
- ☐ No future plans to transfer the management of operations and maintenance activities to an entirely new staff or outsourced company.

◀ Back to KEY STRATEGIES (p. 35)

APPENDIX B - OWNER'S OPERATING REQUIREMENTS

The Owner's Operating Requirements (OOR) can be developed by the owner or the Commissioning Provider either in the Planning Phase or early in the Investigation Phase of a retrocommissioning project. The OOR identifies and documents the owner's comfort requirements such as space temperatures, humidity and outside air fractions, along with the building schedules. A primary objective for compiling and clearly documenting this information is to ensure that, in the course of a retrocommissioning (or retrofit) project, those involved remain sensitive to the owner's and occupants needs. This is especially critical for multi-use facilities where different pressure differentials between spaces as well as different humidity, temperature and schedules can exist. Clearly understanding the owner's needs for the overall building and special areas can greatly reduce mistakes and unwanted disruptions to occupant spaces. The following presents both a template and a completed sample to assist in documenting the Owner's Operating Requirements.

The following pages contain a template and sample document of the Owner's Operating Requirements.

◀ Back to KEY STRATEGIES (p. 35)

Owner's Operating Requirements – Template

Requirement	Typical for Building	Offices	Lobby	Conference Rooms	Computer or Data Storage	Other	Notes
Temperature requirements for cooling and heating seasons							
Humidity requirements							
Dehumidification requirements							
Pressure relationship requirements							
Filtration requirements							
Ventilation requirements							
Air change requirements							
Sound and noise level requirements							
Normal operating schedule for occupancy							
Weekend schedule							
Holiday schedule							
Process and office equipment status during evening/ night time hours							
Process and office equipment status during holiday hours							
Process and office equipment status during scheduled maintenance shut-downs							
Cleaning schedules							
Other Requirements							

◀ Back to KEY STRATEGIES (p. 35)

Owner's Operating Requirements – Sample Document

Operating Requirements for the High Rise Office Building

Requirement	Typical for Building	Offices	Lobby	Conference Rooms	Computer or Data Storage	Other Print Shop	Notes
Temperature requirements for cooling and heating seasons	Occupied: 72° F +/- 2 ° F Unocc. Summer: 78-80 ° F Unocc. Winter: 70 ° F	Same	Same	Same	67 degrees at all times		
Humidity requirements	No direct humidity control by building systems, possible of tenant systems				50 percent		
Dehumidification requirements	None				50 percent		
Pressure relationship requirements	(+) 0.04 diff. pres. Between building interior and outside environment					.(-) 0.02 diff. pres. Between the Print Shop and surrounding areas.	
Filtration Requirements	2" 30% pleated pre-filter – changed as needed. 20" 90-95% bag – changed once per year.						
Ventilation requirements	25% outdoor air	Same	Same	Same	Same	Separate MUA system	
Air change requirements	N/A						
Sound and noise level requirements	N/A	N/A	N/A	N/A	N/A		
Normal operating schedule for occupancy	M-F = 6am-6pm		24 hours, 7 days a week				Equipment is operating 1 hour prior to occupancy
Weekend schedule	Sat = 8am-1pm Sun = N/A						
Holidayschedule	Holiday same as Sunday	Same	Same	Same	Same		
Process and office equipment status during evening/ night time hours	100-300 tons of FC units with chiller water coils serving equipment loads	Same	Same	Same	Same		
Process and office equipment status during holiday hours	Same as evening and night time hours	Same	Same	Same	Same		
Process and office equipment status during scheduled maintenance shutdowns	Same as evening and night time hours						
Cleaning schedules	M-F = 6am-2:30pm						
Other Requirements	All week days and Sat: 5am to 9pm Sundays and Holidays the lights are off and the Garage is locked						

◀ Back to KEY STRATEGIES (p. 35)

APPENDIX C - RETROCOMMISSIONING IMPLEMENTATION PLAN

The Retrocommissioning Implementation Plan (Plan) can be developed by the Commissioning Provider at the end of the retrocommissioning Investigation Phase. This Plan describes and prioritizes each of the retrocommissioning findings, identifies a solution, and outlines the owner's acceptance criteria for correct performance. The Plan can be used to develop a scope of work for the contractor(s) responsible for implementing the retrocommissioning improvements. One Plan can be written that covers all the improvements and repairs or a separate Plan can be developed for each type of improvement. The following presents both a template and a completed sample to assist in developing a clear Retrocommissioning Implementation Plan. Note that the control improvements are the focus for the sample.

◀ Back to KEY STRATEGIES (p. 35)

Retrocommissioning Implementation Plan – Template

The following outlines a plan for implementing the improvements identified during the recent retrocommissioning project for [Building Name and Location]. Retrocommissioning has identified [number] issues as listed below in order of priority:

1. [Name of Issue or Finding]
2. [Name of Issue or Finding]
3. [Name of Issue or Finding]
4. [Name of Issue or Finding]

The following describes each of the issues in detail, proposes a solution, and outlines the acceptance criteria:

1. [Name of Issue]
   Description:
   Proposed Solution
   Acceptance Criteria

2. [Name of Issue]
   Description:
   Proposed Solution
   Acceptance Criteria

3. [Name of Issue]
   Description:
   Proposed Solution
   Acceptance Criteria

4. [Name of Issue]
   Description:
   Proposed Solution
   Acceptance Criteria

◀ Back to KEY STRATEGIES (p. 35)

Retrocommissioning Implementation Plan – Sample

Retrocommissioning Implementation Plan for the High Rise Office Building – Control Improvements

The following outlines a plan for implementing the control improvements identified during the recent retrocommissioning project for the High Rise Office Building located at 1000 Street NW in Controlsville, Washington.

Retrocommissioning has identified five significant issues as listed below in order of priority:

1. Hot water plant control
2. Night low limit control investigation
3. Economizer control modifications
4. Complete programming modifications for warm-up mode
5. Ventilation air preheat control

1. Hot Water Plant Control

Description

At the beginning of retrocommissioning, the hot water plant was in overflow condition, with a temperature differential between the supply and return of only a few degrees. The hot water plant flow has been reduced by lowering the remote differential pressure setpoint, which resets the differential setpoint across the hot water distribution pumps (P-6, 7, and 8). Now, instead of 3 pumps running at 95% speed, 1 pump runs at 50% speed and still meets the hot water load.

The two small (Aerco) boilers operate almost 100% of the time, along with 1 to 3 of the large boilers. See hot water plant schematic attached. Even with reduced system flow, the two small Aerco boilers only add about 2 degrees to the supply water temperature. With such a low TD, it is unclear why these boilers even run. Furthermore, the control sequences say that the Aerco boilers are to be enabled first when loads are low, and then used as trim for the large boilers.

Proposed Solution

1. Compare the sequence as programmed to the written sequence. It may be found that the Aerco boilers are not being controlled properly within the entire sequence of the hot water system. Or, it may be that the secondary hot water flow needs to be further reduced (by lowering the differential setpoint across the pump further) to allow the Aercos to significantly influence the hot water supply temperature. Consider turning off the Aerco boilers whenever boilers 3, 4, or 5 are commanded ON.

2. Remote DP setpoint has already been reduced and secondary pump speed reduced. Check remote DP setpoint and determine if setpoint value can be reduced further to optimize system operation. Program minimum VFD speed for each secondary pump to be 20 Hz (variable).

◀ Back to KEY STRATEGIES (p. 35)

Retrocommissioning Implementation Plan for the High Rise Office Building – Control Improvements

Acceptance Criteria

- The problem will be considered fixed once the programming code is clarified and the Aerco boilers are integrated properly into the hot water system sequence.
- The Control Contractor must document the source of the problem and all changes made.
- The Retrocommissioning Provider will trend the hot water plant after any modifications to verify operation as intended.

2. Night Low Limit Control Investigation

Description

Even when the nighttime outside air temperatures are as high as 50°F, the hot deck air handlers are commanded ON due to the night low limit (NLL) control sequence. The written control sequence says that AHU 5 and 6 will start when "space temperature drops below 60°F" and stops when "the space temperature rises to 63°F."

Proposed Solution

1. Compare the sequence as programmed to the written sequence. Make sure NLL setpoints are properly implemented.

2. Provide a list of zones polled for the NLL control function and note the nighttime zone temperatures from point histories or trending.

3. If one or more zone temperatures are less than 60°F, then the night low limit operation would appear to be warranted.

4. If no zone temperatures are less than 60F, then NLL should not function.

5. The Commissioning Provider will work with the building staff to look for nearby opportunities for infiltration if any zones are identified as driving the night low limit.

Acceptance Criteria

- The problem will be considered fixed once the polled zones are clarified and the NLL sequence is verified to be working properly. The Maintenance Service Contractor and building staff will work to prevent NLL from occurring due to infiltration.
- The Control Contractor must document the source of the problem and any changes made.

◀ Back to KEY STRATEGIES (p. 35)

Retrocommissioning Implementation Plan – Sample (continued)

Retrocommissioning Implementation Plan for the High Rise Office Building – Control Improvements

3. Economizer Control Modifications

Description
The current economizer sequence utilizes differential enthalpy. Due to difficulties with relative humidity sensor maintenance and accuracy, the economizer is not enabled when it should be, thus requiring additional mechanical cooling.

Proposed Solution
Change the economizer control sequence for AHU 1, AHU 2, AHU 3, and AHU 4 to differential dry bulb.

Acceptance Criteria
- The problem will be considered fixed once the economizer is working to provide free cooling as expected. The Controls Contractor must document all changes made.
- The Commissioning Provider will trend all four air handlers for economizers operation after any modifications to verify that the differential dry bulb control strategy is working properly.

4. Complete control modifications for warm-up mode

Description
The Controls Contractor has been working with the Commissioning Provider to implement a corrected warm-up sequence that prevents warm-up from occurring when there is a cooling load or when the building is occupied. The corrected sequence needs to be replicated on AHU 3 and 4, and the outdoor air fan isolation dampers may need to be programmed to close when warm-up is enabled.

Proposed Solution
Make sure the isolation dampers on the outside air fans close during warm-up. Replicate the corrected programming modifications of the warm-up sequence for AHU 3 and 4.

Acceptance Criteria
- The problem will be considered fixed when the warm up sequence for all AHU works as and when expected. The Controls Contractor must document all changes made.
- The Commissioning Provider will test the control strategy using overrides as well as trend warm-up mode operation to verify implementation.

5. Ventilation air preheat control

Description
The preheat coils on the outside air handlers (AHU 7, 8, 9, and 10) are supposed to open when the outside air temperature is below 35°F and modulate to maintain the cooling AHU discharge air temperature setpoint. On many occasions, the preheat coils have been active even on relatively warm days when there is a call for cooling. The preheat does not control to the discharge air temperature of the cooling AHU, but

Retrocommissioning Implementation Plan for the High Rise Office Building – Control Improvements

rather, produces up to 85˚F discharge temperature. It is not clear how the coil is being controlled.

Upon initial investigation, the Commissioning Provider and the Controls Contractor found that the temperature sensor after the preheat coil may not exist, or at least it is has not been found in the control programming.

Proposed Solution

The Control Contractor with help from the building staff will complete the investigation of the source of the control problem at the preheat coil and correct problems with the sequence on AHU 7, 8, 9, and 10.

Acceptance Criteria

- The problem will be considered fixed when the preheat coils work as expected and not during warm days. The Control Contractor must document the source of the problem and all changes made.
- The Commissioning Provider will trend or functionally test all four outside air handlers preheat operation after any modifications to verify operation as intended.

APPENDIX D - RETROCOMMISSIONING IMPLEMENTATION REPORT

The Retrocommissioning Implementation Report can be developed by the Commissioning Provider at the end of the retrocommissioning Implementation Phase. This Report briefly describes each measure identified during the retrocommissioning process, the implementation status, the resolution, and any future recommendations to maintain and enhance system performance.

◀ Back to KEY STRATEGIES (p. 35)

Retrocommissioning Implementation Report – Template

Implementation Report [Insert Building Name]				[Insert Company LOGO] [Contact Name] [Company Address] [Company Phone Number]
Measure	Finding Description	Resolution Status	Resolution Description	Future Recommendations
List the name and number of the RCx measure as it appears throughout the project.	Describe the problem (deficiency) or recommended improvement that was discovered during the RCx Investigation.	Describe the resolution status: Complete, in process, or for future consideration.	Describe how the problem was resolved or what improvement was made to address the deficiency.	If applicable, describe the recommendations needed to help the benefits of the improvement persist over time or describe further work that could help increase the benefits beyond what was done as a result of the RCx project. "No further action required" is an acceptable response.

◀ Back to KEY STRATEGIES (p. 35)

Retrocommissioning Implementation Report – Sample

Retrocommissioning Implementation Report for The Great Office Building

The Retrocommissioning Implementation Report briefly describes each measure identified during the retrocommissioning process, the implementation status, and any future recommendations to maintain and enhance system performance.

Retrocommissioning Implementation Report: The Great Office Building	Prepared by RCx Inc Contract Name] [Company Address] [Company Phone Number]			
Measure	Finding Description	Resolution Status	Resolution Description	Future Recommendations
Pump impeller trim	It was noted during the site assessment that all of the triple duty valves serving the condenser water pumps were throttled to approximately 50%. This indicates that the original pump was designed to provide more head than the system required and the valve had to be throttled back in order to achieve design flow rate. A pump test was conducted to determine the impeller size that would be necessary to achieve design flow with the throttling valves wide open.	Compete	The impellers for condenser water pumps CDP-1 through CDP-9 were trimmed to the appropriate diameter based on the pump tests. In some cases, the impellers were trimmed to the smallest diameter that could be used in the respective pump housing and the throttling valve was then used to tune the system to design flow rate. All of the pump nameplates have been modified to indicate the actual impeller diameter within the respective pump.	No further action is required for this measure unless the required flow rate for any pump change significantly in the future.
Chiller 3 Operational Problems	Chiller 3 is rated at 115 tons and should operate when building loads are 115 tons or less. However the chiller's internal controller was set to prevent the unit from operating above 50% full load amps, which prevented it from satisfying chilled water temperature setpoint. As a result a second chiller would come on-line and contribute to the chilled water plant instability outlined above.	Complete	This measure has been implemented. The internal controller for Chiller 3 has been fixed and the chiller is capable of operating at 100% load without any problems.	It is imperative that Chiller 3 remain capable of operating at 100% load for the chilled water plant to remain stable. Chiller 3 is the base unit and is must carry the load during low-load situations. Any future operational issues associated with Chiller 3 must be corrected immediately; else the chilled water plant may not achieve stable operation if one of the large chillers is required to run to serve a low load.
Economizer Control	Due to unreliable relative humidity sensor measurements, the differential enthalpy economizer control strategy for all cold-deck air handling units (AHU1 through AHU4) was not resulting in an effective use of outdoor air for free cooling. A "differential" control strategy means that the economizer cycle is enabled whenever the outdoor air enthalpy is less than return air enthalpy.	Complete	For this climate zone, dry-bulb air temperature is a more effective economizer control strategy than enthalpy. Hence, the control programming was modified to base economizer operation on differential dry bulb rather than differential enthalpy.	No further action is required for this measure.

◀ Back to KEY STRATEGIES (p. 35)

APPENDIX E - REQUEST FOR PROPOSAL (RFP) CHECKLIST FOR RETROCOMMISSIONING SERVICES

- ☐ Include clear objectives and assign priority to each (energy, comfort, building control, etc.)
- ☐ Provide information about the building. At minimum include:
  - A brief building description
  - Square footage
  - A general HVAC description (central plant as well as distribution systems for both heating and cooling) and controls system description
  - A list of major equipment, including number and age of each type
  - A brief renovation, retrofit, and equipment replacement history
  - A building use description
- ☐ Provide as much information on the trending capabilities of the EMCS as possible. Ideally, a complete points list should be provided. This increases the bidders' ability to more accurately budget the data acquisition tasks. Also, state whether the system can be accessed remotely (by modem or internet).
- ☐ Provide a list of available up-to-date building documentation.
- ☐ Include as complete a scope of work as possible. State the type of retrocommissioning expected (existing-building, new equipment, or combined new and existing systems). If it is unclear what the scope of work can realistically include, allow step one of the project to address developing a detailed scope of work. Or, hire an experienced retrocommissioning consultant to help develop the scope of work for inclusion in the RFP. The scope of work should include a list of equipment needing retrocommissioning. Also, clearly state for each phase of the project (planning, investigation, implementation, and integration) what the in-house building staff and/or service contractor responsibilities include and what the retrocommissioning provider responsibilities include.
- ☐ If the preferred data acquisition methods are known (datalogging, trending, functional testing) state them, otherwise specifically ask that bidders detail their approach on these issues.
- ☐ Indicate what is expected for each of the retrocommissioning phases (planning, investigation, implementation, and hand-off). It is especially important for the bidders to know whether the contract proceeds through the implementation phase or ends with the investigation phase (detailed site assessment).

◀ Back to KEY STRATEGIES (p. 35)

- ☐ Request the retrocommissioning service provider's general approach and a skeletal retrocommissioning plan for the project.
- ☐ List the specific support that the retrocommissioning service provider can expect from the facility staff and service contractors (particularly the controls vendor) and give the skill level of each of the facility staff. State how much testing and investigation can be done by facility staff.
- ☐ When requiring savings calculations/estimates, state the desired method for completing the work (qualitative ranking of measures for implementation using expert judgment, cost estimates and engineering calculations of savings, costs from actual bids and bin or computer simulations of savings).
- ☐ Clearly state any cost or energy savings calculations or estimates required of the retrocommissioning service provider prior to implementation and after post-verification.
- ☐ List the required qualifications of the retrocommissioning service provider and any subcontractors.
- ☐ Request work examples from previous projects (final report, Master List of Findings, etc.).
- ☐ List the RFQ/RFP selection criteria.
- ☐ Give a cost range for the project.
- ☐ Provide a list of required deliverables (see "Selecting a Commissioning Provider" in Chapter 5).
- ☐ Include other specific information as necessary.

◀ Back to KEY STRATEGIES (p. 35)

APPENDIX F - LINKING ENERGY SAVINGS PERFORMANCE CONTRACTS AND RETROCOMMISSIONING

One option for financing some energy efficiency projects is an energy savings performance contract (ESPC) – typically offered by an energy service company (ESCO). These contracts are set up so that the ESCO covers the project costs and is paid back through energy cost savings. This allows owners to avoid investing their own capital and lowers the risk related to the performance of the new equipment.

While an attractive option, an ESPC presents certain challenges when used in conjunction with retrocommissioning. First, because retrocommissioning is often a low-cost investment with high returns, it can create a revenue stream that the owner may not want to pass on to an ESCO. In addition, retrocommissioning may not fit well into the business model of most ESCOs due to its reliance on labor rather than on installation of equipment. As a consequence, it may be difficult to find an ESCO interested in a thorough retrocommissioning project.

If an owner does pursue retrocommissioning through an ESPC, there are issues to consider. Bundling retrocommissioning O&M improvements with retrofits and equipment replacement may increase the overall financial appeal of the project and achieve a higher degree of improvement in building performance. When considering use of ESPCs in conjunction with retrocommissioning, owners should take steps to ensure that the process is as effective as possible:

1. Complete the retrocommissioning process first, if appropriate. A major retrofit project is the perfect time to do retrocommissioning so that the new equipment is properly selected and installed to function correctly as a system. Completing retrocommissioning as a first step allows the owner to receive all the associated cost savings by keeping it out of the financial agreement with the ESCO. Only necessary capital measures are financed with the ESCO.

2. Where retrocommissioning is implemented prior to finalizing an energy savings agreement, it is critical that the owner inform the ESCO of the project and provide a copy of the Final Report. The ESCO will need to use recent utility bills, post-retrocommissioning, to determine an energy baseline. If not, the baseline will be inaccurate since the retrocommissioning savings are not included.

3. New equipment, whether installed under an ESPC or paid for directly as a capital expenditure, should be commissioned. This type of commissioning, however, often stops short of the holistic perspective of retrocommissioning, which evaluates how new equipment interfaces with existing systems and their performance. When retrocommissioning is conducted as a part of an ESPC, the provider ensures that the performance of new equipment is not hindered as a result of interfacing with the existing equipment, components, or systems that may be malfunctioning.

◀ Back to KEY STRATEGIES (p. 35)