# Guidelines for Incorporating Commissioning into Energy Savings Performance Contracts

**Prepared for**
**US DOE Federal Energy Management Program**

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# 1. Introduction

Energy savings performance contracts (PCs) using the international measurement and verification (M&V) protocols are increasing in number. For these projects to be successful, they must incorporate an appropriate quality assurance and quality control component. M&V protocols call for commissioning on all projects.

Energy savings performance contract projects (PCs) are services and products provided by a contractor having specific levels of performance attached to them. Often payment for the service is benchmarked and dependent on how well the levels of performance are met over time, based on actual measurement and verification. Services include engineering analysis; project management; and providing equipment, installation, operation and maintenance. The focus of the project is to obtain utility bill savings from energy and peak demand reductions and to use those savings to pay for the improvements that led to them.

For any PC to be successful, an appropriate quality assurance and quality control component needs to be part of the process. In addition, PCs require a measurement and verification (M&V) component to assess the energy performance of the installed systems. The International Performance Measurement and Verification Protocol (IPMVP) has become the standard for M&V. Commissioning has proven to be a useful process for ensuring quality in the design and construction of mechanical and control systems and is a standard requirement in all M&V options of the IPMVP.

Commissioning new equipment is defined as "the process of ensuring that systems are designed, installed, functionally tested and capable of being operated and maintained to perform in conformity with the design intent." (ASHRAE, 1996) A similar definition is given in The International Performance Measurement and Verification Protocol (IPMVP, 1997): "A process for achieving, verifying and documenting the performance of buildings to meet the operational needs of the building within the capabilities of the design, and to meet the design documentation and the owner's functional criteria, including preparation of operator personnel." (IPMVP, 1997, p. 145) For maximum effectiveness, commissioning begins in the design phase with design intent development and documentation, and continuing through construction, acceptance and the warranty period with actual testing and documentation of operation and performance.

The most appropriate commissioning process used for PC projects is likely to differ significantly from the commissioning process used in a typical non-PC new construction or major renovation project. In the extreme, PC contracts have felt that there is no need for an outside commissioning authority and process. On the other hand, owners are interested in more than just the energy savings. They want to ensure that all installed equipment and interfaced systems work as intended in all modes of operation, regardless of energy impact. How can the non-energy issues be dealt with in performance contracts? Normally, if M&V is more rigorous, the commissioning rigor could be reduced and vice versa, but how is this distribution best made? Both M&V and commissioning have some common data needs. How can these needs be coordinated?

This guideline discusses these and other important issues related to commissioning performance contract projects. It provides a description of the basic commissioning and PC process, then discusses the issues surrounding commissioning and M&V, and finally provides specific guidance for integrating commissioning into performance contract projects.

# 2. Commissioning and Performance Contract Objectives and Process

M&V is not a replacement for commissioning and commissioning is not a replacement for M&V. Commissioning's primary objective is to ensure that equipment *functions* well according to the specifications and has the *potential* to save energy. M&V seeks to *quantify the savings* of the installed equipment. PCs ultimately seek to ensure that the systems *save the energy* they were estimated to. These are important distinctions. Meeting the commissioning objectives does not mean the PC goals will be met. For example, a variable speed drive installation may function flawlessly, but not save the energy expected because the original savings estimates or the post savings calculations (M&V) were inaccurate. Conversely, a variable speed drive on paper may save the energy predicted, but not actually function well, if the pre- or post-savings estimates (M&V) were inaccurate. Good M&V and commissioning are both important in a PC.

## 2.1. Commissioning

For new equipment, typical commissioning objectives and methods during the design phase include:

- Ensuring that the design intent is clearly documented—*by providing formats, coordinating its development and reviewing content.*
- Ensuring that commissioning requirements, functional and performance criteria, operation and maintenance (O&M) documentation and training are completely specified in the bid documents—*by coordinating their development, providing content and reviewing the documents.*
- Contributing to the design documents—*through focused design reviews.*

Commissioning during the construction phase typically is intended to achieve the following specific objectives:

- Verify that applicable equipment and systems are installed according to the manufacturers' recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing contractors—*by submittal review, construction observation and review of start-up and checkout.*
- Verify and document proper function and performance of equipment and systems—*through documented functional and performance testing.*

- Verify that O&M documentation left on site is complete—*through documentation review.*
- Verify that the Owner's operating personnel are adequately trained—*through review of training plans and verifying training completion.*

Commissioning often extends into the contractor's normal one-year warranty period. The objectives of commissioning during warranty are to:

- Ensure that system meets the design intent during peak seasonal conditions—*through conducting required seasonal or deferred testing.*
- Bring to closure outstanding functional and performance issues—*by reviewing and addressing outstanding issues.*

## 2.2. Energy Savings Performance Contracts

The primary objectives and activities for typical PCs include:

- Determining whether savings are likely to pay for capital and financing costs for the candidate building over an acceptable time horizon—*by performing a preliminary building assessment and identifying primary savings sources.*
- Developing a comprehensive list (with savings estimates and costs) of utility (energy, water, waste, etc.) and operations and maintenance (O&M) cost reduction measures—*through a detailed "investment grade" audit and energy study.*
- Developing an acceptable contract with the owner.
- Developing project details—*through engineering analysis and design for the measures.*
- Installing and setting up equipment and systems and ensuring full functionality and performance—*through a traditional design-build program with contractors providing their own quality control and assurance.*
- Verifying energy savings (M&V)—*through engineering calculations, spot measurements, short or long-term monitoring, bill analysis and/or building simulation.*

**M&V Options.** The IPMVP describes four verification of energy savings or M&V options (IPMVP, 1997). More than one option may be used on any given project.

*Option A. Verify functionality. Spot measurement. Stipulate savings assumptions.* Verify that the measure can generate savings. Key performance factors (lighting wattage or chiller efficiency) are determined with spot or short-term measurement. Operational factors (lighting operating hours or cooling ton-hours) are stipulated based on analysis of historical data or spot/short-term measurements and agreement with the owner. Performance factors and proper operation may be measured or checked annually. Savings are calculated using spot or short-term measurements, computer simulations, and/or historical data.

*Option B. Verify functionality. Whole-building simulation or end-use calculations from short-term measurements over life of contract.* Savings are determined after project completion by short-term or continuous measurements taken throughout the term of the contract at the *device or system level.* Both performance and operational factors are monitored.

*Option C. Verify functionality. Whole-building energy use tracking over time.* After project completion, savings are determined at the "whole-building" or facility level using current year and historical utility meter or sub-meter data. Savings are calculated using a range of methods from simple comparison to multivariate regression.

*Option D. Verify functionality. Calibrated whole-building simulation informed from short-term measurement.* Savings are determined through simulation of facility components and/or the whole facility. Simulations are calibrated with hourly or monthly utility billing data and/or end use metering.

Ideally, an independent party should perform the M&V to ensure the highest objectivity. However, in practice many PC contractors perform their own M&V in order to reduce overall project costs and keep the project viable. This scenario puts the owner at more risk. This risk can be mitigated to some degree if the technical and commissioning specifications are more rigorous, and if the owner has staff or a consultant who can technically evaluate and review the M&V work performed by the PC contractor.

## 2.3. Commissioning in M&V Protocols

The IPMVP references commissioning more than 13 times. The protocol highly recommends commissioning for all PCs for the following tasks: (IPMVP, 1997)

- Documenting design assumptions
- Documenting energy conservation measure design intent
- Installation verification
- Functional performance testing
- Adjusting measures to meet actual needs

The IPMVP (protocol) definition of commissioning also suggests that operator training "preparation of operator personnel" can be enhanced through commissioning.

The protocol recommends using ASHRAE Guideline 1-1996 *The HVAC Commissioning Process* as a guide. The protocol also suggests that M&V data can be used for commissioning and that commissioning can help installers do a better job and reduce owner risk. The protocol notes that the performance contractor normally would do the commissioning, but that the owner may engage an independent third party. Equally specific references to commissioning are found in the Federal Energy Management Program (FEMP) M&V Guidelines where commissioning is recommended for all M&V options.

### 2.4. M&V and System Type

Both the IPMVP and FEMP protocols classify installed systems as either simple or complex. Simple systems are characterized by constant load, constant operating hours. Simple systems also include static measures, such as lighting, some motors, windows and insulation. Complex measures have variable load or variable operating hours, such as lighting schedule controls, steam traps, variable speed drives, variable air volume retrofits, boiler or chiller replacement, packaged rooftop replacement and outdoor air control. The recommended M&V rigor increases as the installed systems become more complex.

## 3. Why Commission With M&V?

Understanding why commissioning is important even when the project has M&V requires discussion about risk relative to the performance of energy and non-energy related measures.

### 3.1. Risk, M&V and Commissioning

Commissioning ensures that systems are installed and operating as intended and subsequently reduces the uncertainty about whether the owner will receive all the savings he or she purchased. The risk the owner assumes decreases as more commissioning and M&V are applied to any given measure. However, increased effort in these areas also increases project costs.

There is an appropriate level of M&V and commissioning for each measure, dependent on the owner's aversion to risk and the types of measures installed. Generally, with more M&V, commissioning may be less rigorous. And the more rigorous the commissioning, the less the need for M&V. However, there is never a point where a PC requires neither some M&V nor commissioning.

### 3.2. Performance Contractor and Commissioning

Many building owners assume that performance contractors will commission their projects. After all, contractors will end up paying for poor performance, if they don't commission their projects well. In actual practice, if the predicted savings are not realized (partly or solely because the system was not commissioned well) contractors can often use some latitude in their savings analysis assumptions and thus minimize the short-fall of savings. That is, if the contractor poorly commissions the project and the energy components of the systems don't function as well as they could, the owner may never know, predicted and/or maximum savings may never be realized and the contractor is unlikely to be adversely affected. The owner is likely to be left with the non-energy problems.

The contractor's main goal is to install the equipment and receive payment for the installation (which usually includes a significant markup) and to install it well enough to realize the predicted energy savings. Many projects are based on stipulated savings. In these cases, since savings are based on agreed upon parameters such as operating hours

and not completely measured after the fact, contractors may have less motivation to do good commissioning. In addition, some contractors' definition of commissioning is doing start-up checkout, traditional testing, adjusting and balancing or controls calibrations.

Many PC contractors hold the opinion that their projects do not require an outside commissioning authority and process. However, most owners are interested in more than just the energy savings. They want to ensure that all installed equipment and interfaced systems work as intended in all modes of operation, regardless of energy impact. Some major performance contractors have report that they are compensating customers for projects where performance was lower than estimated. Investigation into these problem projects by performance contractor forensic staff reveals that in many cases poor performance was caused by inadequate quality control during design, installation and setup. Investigators believe that a commissioning process could have prevented many of the problems they are now paying for. On the positive side, integrating the appropriate portions of the traditional commissioning process into PCs can result in an improved project. (Fiedler 1998)

Commissioning, in fact, can offer real benefit to contractors. Commissioning can result in better customer satisfaction, more referrals, fewer callbacks and improved energy performance and payments—all of which contribute to greater profitability. So why aren't performance contractors all doing it? One supposition is that the people responsible for executing quality assurance and control (designers during design and site technicians during construction) are not informed that their designs and installations are faulty. Upper management in PC companies apparently has been more focused on energy analysis and establishing baselines than on quality control of design and installations.

# 4. Integrating Commissioning Into PCs

The previous sections of this guideline provided the background in the subject of commissioning and PCs. This section provides specific guidance for incorporating commissioning into PCs. A few salient issues are discussed prior to providing a full table of recommendations.

## 4.1. Managing vs. Executing Commissioning

Some commissioning guidelines refer to the party managing the commissioning as the commissioning agent, authority or provider, while others reserve that term for the party executing the in-field commissioning. When the performance contractor executes the commissioning field work, the owner should hire or assign someone to manage that commissioning. An independent commissioning provider hired by the owner manages and may also execute some of the field commissioning. Table 1 in section 4.9 delineates the commissioning roles of the performance contractor, the owner's technical representative and the independent commissioning provider.

## 4.2. Specifications and Design Documents

Many PCs are design-build projects where the owners traditionally receive limited specifications and design documents. Owners need to communicate from the onset that

they require more substantive project specifications and design documents, including design narratives for all systems and that detailed specifications and drawings prior to construction. This design information will be invaluable to those responsible for commissioning, M&V and the long-term operation of the facility. This information is critical for any substantive commissioning design reviews. If the project schedule or other conditions are likely to not allow detailed specifications and design documentation, the owner can include the specific language desired in the specifications, right in the owner/contractor contract.

## 4.3. Financing Commissioning and Conflicts of Interest

Because commissioning costs can impact a project's first costs, commissioning is often seen as a cost to minimize or eliminate. Obviously, owners should incorporate only the amount of commissioning that is appropriate for a given project. Owners can further minimize commissioning costs by creatively managing and financing commissioning.

The cost of commissioning can be added into the total project cost and financing package. This is generally the most desirable option for owners from a financing view. For owners who are cash-constrained, it may be the only option. For projects where commissioning will be financed, the commissioning provider will have to be contracted to and paid by the performance contractor and therefore is not truly "independent," though owners may retain the right to select their commissioning providers.

A conflict of interest exists with any project where commissioning is conducted by a party involved in the design or construction of the project. This conflict should be specifically addressed to minimize the potential problems. For such projects, the owner should ensure that more detailed commissioning specifications are written so that there is no question as to the commissioning tasks required, including the expected level of testing and documentation rigor and the specific performance targets (EER, kW/ton, capacity, space temperature range, etc.).

In order to deal with conflicts of interest during planning, owners must clearly state their commissioning desires and objectives prior to the development of the performance contract. One option is for the owner to select an independent commissioning provider beforehand and require that the performance contractor use this party to do the commissioning work. Owners may have the commissioning provider assist in developing the commissioning scope of work. Another option is for owners to develop some strict qualification criteria for the commissioning provider and require the performance contractor to hire another firm that meets these criteria to perform the commissioning work. Owners can also maintain final approval of the commissioning firm selected.

During design and construction owners should require the commissioning providers to report all findings and issues as they are identified directly to both the owner and to the performance contractor, so the owner has full knowledge of all findings and issues. This reporting mechanism is also recommended for any commissioning done by the performance contractor, with reports from the individual staff of the contractor doing the commissioning going simultaneously to the PC supervisor and to the owner. When the commissioning provider is under contract to the performance contractor, it is advised that

the level of technical expertise and the time commitment to the project of the owner's technical representative be greater.

## 4.4. M&V and Non-Energy Components

Most PCs are focused on the energy consumption of the equipment or systems they cover, since that forms the basis of their payments. However, many operational and performance issues are equally if not more important than energy to the owner, such as, alarm annunciation, chiller system flow safeties, air handler low temperature limit and high duct pressure safeties, pipe cleaning and water treatment, compressor staging and loading, equipment interfaces with fire-alarms and emergency power, building automation system graphics features, isolations valves for maintenance, manual control, operation of lead/lag controls, building pressurization, indoor environmental quality (see section 4.5), O&M and as-built documentation, staff training, etc.

These features may be of little importance to the performance contractor and subsequently may receive inadequate attention and verification of proper operation. Even though the contractor may be involved with the project for some years, if these non-energy issues are not identified before the typical one year warranty, any assistance with these types of issues will cost the owner more money. Ensuring that non-energy issues are adequately addressed is one of the primary reasons for incorporating commissioning into every PC.

## 4.5. Indoor Environmental Quality Verification

One area where significant overlap may exist between the M&V and commissioning is the verification that indoor environmental quality (IEQ) meets project targets (either improved performance or no degradation from pre-project levels). Generally, commissioning providers are intimately familiar with the issues surrounding IEQ. Performance contractors, having historically been focused on energy, are less likely to be "experts" in the IEQ arena. That makes the traditional commissioning provider on the project the natural candidate to assist if not conduct any IEQ verification for either the owner or performance contractor. An IEQ appendix to the IPMVP provides excellent guidance on verifying IEQ performance. (IPMVP 1999 Appendix). Owners should read Section 8.6 and Table 8.2 of this appendix during planning and include as part of the contract documents the IEQ issues they want verified and designate a party the responsibility to perform the verification.

## 4.6. Simple Systems

For simple systems it is generally recommended that the performance contractor execute the field commissioning work with oversight by the owner's technical representative. For simple systems, there is less risk for the owner, as savings are relatively easy to calculate with higher confidence than for complex measures. Commissioning is also easier for simple systems and the commissioning effort can be verified by staff with less technical experience, which allows the owner to more easily and confidently manage the commissioning executed by a the performance contractor. However, more detailed specifications and independent design and contract setup review is warranted. This

scenario requires that the owner has or engages a technical representative who can manage the technical quality assurance on the project. The owner or owner's representative should provide clear direction to the performance contractor in the contract documents regarding what non-energy issues and features are to be verified.

The owner may be able to reduce their level of oversight, review and verification of the commissioning effort by the performance contractor as the M&V becomes more rigorous from Stipulated (IPMVP Option A) to Performance (Options B, C; D) for a any given measure.

## 4.7. Complex Systems

It is generally recommended that with complex systems, commissioning oversight or management be handled by an independent commissioning provider hired directly by the owner. However, the performance contractor may do the bulk of the field commissioning work. This scenario, with an independent commissioning provider and the contractor doing much of the field work, still requires detailed and clear specifications and commissioning requirements in the contract documents. The owner's technical staff may be able to perform the commissioning oversight function without an independent commissioning provider, if they have the technical and managerial skills and sufficient time.

As with simple systems, the owner may be able to reduce the independent commissioning provider's level of oversight, review and verification by transferring some of the effort to the performance contractor as the M&V becomes more rigorous from Stipulated (IPMVP Option A) to Performance (Options B, C; D). The owner or owner's representative should provide clear direction to the performance contractor in the contract documents regarding what non-energy issues and features are to be verified.

## 4.8. Projects of Mixed System Types

PCs with a mix of complex and simple measures could have the commissioning managed by the independent commissioning provider, with the simple system commissioning work primarily conducted by the performance contractor, as described above and as listed in Table 1. In such situations, careful communication protocol is required to reduce the number of misunderstandings or disagreements as to scope and accountability. The independent commissioning provider normally will not have authority over the performance contractor, increasing the need for good communication and coordination.

## 4.9. Guidelines for Incorporating Commissioning into Energy Savings Performance Contracts

Both the management and suggested commissioning rigor by outside (non-PC contractor) parties is a function of the system or equipment type and the M&V option selected. Subsequently, this section provides guidance organized by system type and M&V type. However, it should be recognized that the M&V option selected may also be a function of the type of commissioning chosen.

Table 1 shows the typical commissioning activities divided up into 15 tasks. Details about these tasks can be found in various commissioning guidelines (for instance, ASHRAE, 1996). With each task, the suggested scenario for managing and executing the work is provided for Simple Systems and Complex Systems and two categories of M&V: *Stipulated* (IPMVP Option A) and *Performance* (IPMVP Options B, C; D). These categorizations (Stipulated and Performance) are the authors' and are not described this way in the IPMVP. Table 1 provides a summary of guidelines for incorporating commissioning into PCs.

The tasks in the following table are assigned to three parties:

- The energy savings performance contractor (ESCO)
- The independent commissioning providers (ICP)
- The owner's technical representative (OTR)

The independent commissioning provider is ideally hired by the owner, but may be hired by the ESCO, with approval by the owner. The ICP reports all findings to both the owner and the ESCO.

The owner's technical representative may or may not be on the owner's staff. This person need not have extensive engineering skills, but does need to have technical skills and understanding of the technologies being considered and an understanding of M&V

**Table 1. Incorporating Commissioning into ESPC**

## Simple Systems Commissioning

| Project Tasks | **Simple Systems** (constant load, constant operating hours; static measures: lighting efficiency, some motors, windows, insulation) | |
|---|---|---|
| | **Stipulated (IPMVP Option A)** | **Performance (IPMVP Option B, C; D)** |
| General management and overview | • Cx provided by ESCO. Detailed oversight by OTR. Use detailed specifications.<br>• Initial contract setup needs independent review. | • Cx provided by ESCO with less oversight by OTR than Option A.<br>• Initial contract setup needs independent review. |
| Scoping assessment | • Performed by ESCO<br>• OTR does walk-through | • Performed by ESCO<br>• OTR does walk-through |
| Investment grade audit, baseline and proposal (incl. Spot measurement) and simulation | • Performed by ESCO<br>• ICP review the baseline & audit<br>• ICP provide commissioning requirements for ESCO proposal | • Performed by ESCO<br>• ICP or OTR review the baseline and audit |
| Contract development | • Performed by ESCO<br>• ICP or OTR review to ensure Cx is required, and to review other issues, if needed (M&V) | • Performed by ESCO<br>• ICP or OTR review to ensure Cx is required, and to review other issues, if needed (M&V) |
| Design and specification review (verify owner's project requirements, Cx, IEQ, training & O&M in specs) | • Performed by ICP | • Performed by OTR (or ICP) |
| Submittal review<br>(match to specifications, ensure clear sequences) | • Performed by OTR (or ICP) | • Performed by OTR (or ICP) |
| Construction observation & installation verification | • Performed by OTR (or ICP) | • Performed by OTR (or ICP) |
| Pre-functional checklists and start-up | • Performed by ESCO, with spot checking by OTR (or ICP) | • Performed by ESCO, with spot checking by OTR (or ICP) |
| Functional testing | • Tests written and performed by ESCO; witnessed by OTR or ICP | • Tests written and performed by ESCO; witnessed by OTR (or ICP). Tests less rigorous than Option A |

| Project Tasks | **Simple Systems**<br>(constant load, constant operating hours; static measures: lighting efficiency, some motors, windows, insulation) | |
|---|---|---|
| | **Stipulated**<br>**(IPMVP Option A)** | **Performance**<br>**(IPMVP Option B, C; D)** |
| Trending and datalogging for initial functional performance | • When needed, provided and analyzed by ESCO. Reviewed by OTR or ICP | • When needed, provided and analyzed by ESCO. Review optional by OTR or ICP |
| Initial spot efficiency performance testing for M&V (lighting Watts, EER, kW/ton, boiler effic.) | • If needed, performed by ESCO | • If needed, performed by ESCO |
| Facility staff training | • Performed by ESCO<br>• Approved by OTR (or ICP) | • Performed by ESCO<br>• Approved by OTR (or ICP) |
| O&M documentation review | • Performed by OTR (or ICP) | • Performed by OTR (or ICP) |
| One year warranty period activities (optimization, outstanding punch) | • Optimization by ESCO<br>• Punch by OTR (or ICP) | • Optimization by ESCO<br>• Punch by OTR (or ICP) |
| Ongoing monitoring, M&V, IEQ, annual efficiency check, bill analysis, savings | • Not applicable | • Data and analysis by ESCO or independent M&V contractor<br>• Review by ICP or other consultant |

## Complex Systems Commissioning

| | **Complex Systems**<br>(variable load or variable operating hours: lighting schedule controls, steam traps, VFDs, occupancy sensors, VAV retrofits, boiler, chiller and packaged rooftop replacement, outside air control) | |
|---|---|---|
| **Project Tasks** | **Stipulated**<br>**(IPMVP Option A)** | **Performance**<br>**(IPMVP Option B, C; D)** |
| General management and overview | • Cx oversight provided by ICP<br>• ESCO or ICP do bulk of work<br>• More detailed oversight by ICP, than with Options B, C | • Cx oversight provided by ICP<br>• ESCO or ICP do bulk of work |
| Scoping assessment | • Performed by ESCO<br>• ICP does walk-through | • Performed by ESCO<br>• ICP does walk-through |
| Investment grade audit, baseline and proposal (incl. spot measurement) and simulation | • Performed by ESCO<br>• ICP review the baseline and audit | • Performed by ESCO<br>• ICP review the baseline and audit |

| | **Complex Systems**<br>(variable load or variable operating hours: lighting schedule controls, steam traps, VFDs, occupancy sensors, VAV retrofits, boiler, chiller and packaged rooftop replacement, outside air control) | |
|---|---|---|
| **Project Tasks** | **Stipulated**<br>**(IPMVP Option A)** | **Performance**<br>**(IPMVP Option B, C; D)** |
| Contract development | • Performed by ESCO<br>• ICP review to ensure Cx is required, and to review other issues, if needed (M&V) | • Performed by ESCO<br>• ICP review to ensure Cx is required, and to review other issues, if needed (M&V) |
| Design and specification review (verify design intent, Cx, IEQ, training & O&M in specs) | • Performed by ICP | • Performed by ICP |
| Submittal review<br>(match to specifications, ensure clear sequences) | • Performed by ICP | • Performed by ICP |
| Construction observation & installation verification | • Performed by ICP | • Performed by ICP |
| Pre-functional checklists and start-up | • Performed by ESCO, with spot checking by ICP (or OTR) | • Performed by ESCO, with spot checks by ICP (or OTR) |
| Functional testing | • Tests written by ICP (or ESCO); approved by ICP<br>• Tests executed by ICP (or ESCO); approved by ICP<br>• If ESCO executes, ICP witnesses, as needed | • Tests written by ICP (or ESCO); approved by ICP<br>• Tests executed by ICP (or ESCO); approved by ICP<br>• If ESCO executes, ICP witnesses, as needed. Less rigorous than Option A |
| Trending and datalogging for initial functional performance | • Data provided by ESCO<br>• Analysis by ESCO (or ICP); approved by ICP | • Data provided by ESCO<br>• Analysis by ESCO (or ICP); approved by ICP. Less rigorous than Option A |
| Initial spot efficiency performance testing for M&V (lighting Watts, EER, kW/ton, boiler effic.) | • Tests written by ICP (or ESCO); approved by ICP<br>• Tests executed by ICP (or ESCO); approved by ICP<br>• If ESCO executes, ICP witnesses, as needed | • Tests written by ICP (or ESCO); approved by ICP<br>• Tests executed by ICP (or ESCO); approved by ICP<br>• If ESCO executes, ICP witnesses, as needed |
| Facility staff training | • Performed by ESCO<br>• Approved by ICP | • Performed by ESCO<br>• Approved by ICP |
| O&M documentation review | • Performed by OTR (or ICP) | • Performed by OTR (or ICP) |

| | **Complex Systems**<br>(variable load or variable operating hours: lighting schedule controls, steam traps, VFDs, occupancy sensors, VAV retrofits, boiler, chiller and packaged rooftop replacement, outside air control) | |
|---|---|---|
| **Project Tasks** | **Stipulated**<br>**(IPMVP Option A)** | **Performance**<br>**(IPMVP Option B, C; D)** |
| One year warranty period activities (optimization, outstanding punch) | • Optimization by ESCO<br>• Punch by OTR (or ICP) | • Optimization by ESCO<br>• Punch by OTR (or ICP) |
| Ongoing monitoring, M&V, IEQ, annual efficiency check, bill analysis, savings | • Not applicable | • Data and analysis by ESCO or independent M&V contractor<br>• Review by ICP or other consultant |

**Cx** = commissioning, **ESCO =** energy services company (performance contractor), **IEQ** = indoor air quality, **ICP =** independent commissioning provider, **OTR =** owner's technical representative, **VAV** = variable air volume, **VFD** =variable frequency drive.

# 5. Retrocommissioning and PCs

The previous sections of this paper have focused primarily on commissioning new equipment installed through performance contracts. This section provides specific guidance for incorporating retrocommissioning, or the commissioning of existing building systems, into a performance contract and how the retrocommissioning process interfaces with performance contracting outside of the PC, if the two processes take place at or near the same time. With a major PC retrofit, ideally the new equipment should be commissioned and the existing systems retrocommissioned to mitigate any negative impacts the old existing equipment could have on the performance of the new equipment. An example of this might be installing a new building automation system with building static pressure control. For the new system to work properly the existing system exhaust fans and rooftop units should be retrocommissioned to allow proper operation of the new system.

Not only would owners benefit from incorporating retrocommissioning into performance contracts, but performance contractors and commissioning providers can benefit from the marketing potential this arrangement offers. The performance contractor who incorporates retrocommissioning would have a broader range of services to offer, making his performance contract package more complete, higher in energy savings, and more profitable. The commissioning provider gains an opportunity to market commissioning services through the performance network, reach more customers, and possibly have the commissioning work financed through the performance contractor. An owner or performance contractor should not shy away from performing retrocommissioning simply because of a perception of conflict between the two processes.

## 5.1. Retrocommissioning

Retrocommissioning (RCx) is an event in the life of a building that applies a systematic investigation process for improving and optimizing a building's operation and maintenance (O&M). This process usually focuses on energy-using mechanical equipment, lighting, and related controls. The process is intended not only to optimize how equipment and systems operate, but also to optimize how the systems function together. Because retrocommissioning is primarily concerned with low-cost energy savings (often overlooked by the performance contractor), the cost-effectiveness of the retrocommissioning process is usually much better compared to the installation of capital-intensive equipment. If the cost of the retrocommissioning were financed over a typical performance contract project life of say five to ten years, the energy and O&M cost savings would normally result in substantial net positive cash flow back to the owner, contractor, or project.

## 5.2. Timing and Coordination with the PC Contractor

Retrocommissioning may be performed prior to, during, or after completion of a performance contract. Regardless of whether the a retrocommissioning study takes place inside or outside of a performance contract, or before or during a performance project, close coordination between the retrocommissioning provider and the performance

contractor is essential. This includes informing the performance contractor of any and all retrocommissioning activities and providing a report to the performance contractor so that baseline adjustments may be made. If the both the retrocommissioning provider and the performance contractor are hired independently by the owner, it is important for the owner to make introductions, define roles and clearly delineate responsibilities and data-sharing requirements.

**Retrocommissioning before the Performance Contract.** There are two primary reasons for performing retrocommissioning *before* a performance contract: 1.) The savings will remain with the building or owner – rather than become part of the performance contract financial agreement, and 2.) The existing equipment is optimized first so only the most appropriate capital measures are incorporated in the performance contract.

Two important factors to take into account when considering retrocommissioning prior to the performance contract include:

1. Retrocommissioning efforts may take away some very cost-effective, low-cost savings opportunities, thus reducing the cost-effectiveness of the performance contract or limiting the measures that could be incorporated into the contract.
2. If retrocommissioning is performed up to a year before the performance contract, it will be difficult to establish a sound performance contract baseline. Without an accurate baseline, savings cannot be accurately measured.

When retrocommissioning is performed within a year prior to the performance contract, the baseline building conditions are altered and the establishment of the baseline model using 1-3 years of pre-performance contract energy bills is considerably more difficult unless the impacts of retrocommissioning are precisely known. If a major retrocommissioning effort is planned before a performance contract, either the performance contract should be delayed at least a year after the end of the retrocommissioning or the retrocommissioning should incorporate rigorous pre- and post monitoring and possible building simulation in order to precisely know what effect the retrocommissioning had on original conditions. The credibility of a performance contract is based on establishing a proper baseline by which savings can be measured.

**Retrocommissioning during the Performance Contract.** Major reasons for performing retrocommissioning *during* a performance contract performance contract are: 1.) To ensure that new equipment performance is not hindered by old, malfunctioning systems or equipment, and 2.) The retrocommissioning savings can leverage a PC project to improve its overall cost-effectiveness and increase the overall project viability.

Two important factors to take into account when considering retrocommissioning during the performance contract include:

1. Who will act as the retrocommissioning contractor? The performance contractor or an independent party? (See Table 1 in Section 4.9 for a recommended breakdown of commissioning responsibilities between the performance contractor and an independent commissioning provider.)
2. Owners should be cautious when allowing low-cost operational measures which could have short measure lives to take on the longer measure life of the capital performance contracting measures in the performance contract

package, especially for deemed or stipulated savings contracts, and take steps to ensure persistence of low-cost measures.

Integrating retrocommissioning into a performance contract allows the owner to sole-source a complete, comprehensive energy project (capital-intensive measures and low-cost measures). Performance contracts usually only consider the more capital-intensive measures that are easy to verify and that offer safe bets that the stated savings will be realized. A typical performance contract usually passes over or at best lightly touches on any significant low-cost opportunities that may be present in the building due primarily to the perceived difficulty in verifying or guaranteeing these savings, or the low perceived persistence. In the overall performance contract savings summary, retrocommissioning can be considered as a line item energy conservation measure (ECM) and be bundled as such just like any other. Because of the normally better paybacks with retrocommissioning low cost measures, when these are bundled into a performance contract the extra flexibility in developing a project afforded by the better economics might mean the difference between the project becoming viable or not.

There are times when a retrocommissioning study and performance contract may be under development at or near the same time under separate contracts with the owner. If properly executed the total project can result in an overall project greater than the sum of its individual parts. If the retrocommissioning provider is not well equipped to implement the retrocommissioning findings, then the study can be turned over to the performance contractor to consider implementation of the findings. The performance contractor may rewrite the retrocommissioning study to ESCO specifications to ensure that pricing, margins, and calculation techniques are consistent with his standard of doing business. If this is the case, then any gross differences from the original retrocommissioning study should be investigated.

**Retrocommissioning after the Performance Contract.** Reasons for performing retrocommissioning *after* a performance project (if permitted by the performance contractor) include 1.) To ensure that the newly installed equipment performs optimally itself and in relation to other building systems, 2.) To maximize the commissioning dollar by utilizing the knowledge of actual, as-occupied building conditions gained during the performance project, and 3.) To provide extra assurance that the savings potential of performance contract project is met.

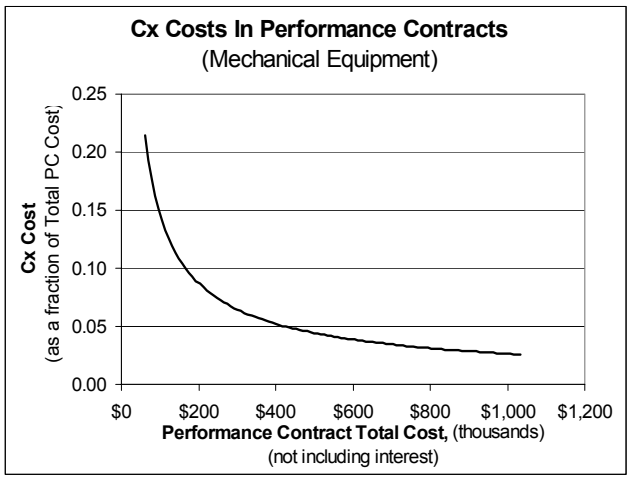
If retrocommissioning is performed during the term of the performance contract when monitoring and bill analysis is still being done, then be sure to make careful measurements of retrocommissioning impacts so that the performance contract baseline can be adjusted accurately.

# 6. Cost of Commissioning in Performance Contracts

## 6.1 Commissioning New Equipment

Costs guidelines shown in the figure below for commissioning new performance measures include design review, writing testing requirements, developing a brief commissioning plan, submittal review, writing tests, conducting tests, trending or

datalogging, verifying training and O&M documentation, developing a brief final report, and seasonal testing. These activities may be provided by an independent commissioning provider, the performance contractor, or distributed between these parties.




Because full building commissioning is rarely done in conjunction with performance contracts, the costs associated with this level of commissioning are not discussed here. The graph at left depicts the range of commissioning costs of only the new equipment installed under a performance contract and critical components and features of other equipment that directly interface with and are affected by the installation. (For example, for a chiller replacement the functions of the existing primary pump and cooling tower would also likely be commissioned, but the existing secondary chilled water pumps probably would not be.) The costs do not include any M&V costs other than verification of equipment efficiency. The graph line provides the center of a range for commissioning costs in relation to the total cost of a performance contract. The costs can vary as much as 50% in either direction. This graph is not intended as the sole source to use in budgeting actual projects, but provides a good benchmark for comparison with built-up budgets.

### 6.2 Retrocommissioning

The following table provides some guidelines for retrocommissioning focused on identifying energy savings. The costs are for typical buildings of various types (office, hospital, university, etc.) over 100,000 sf. Retrocommissioning in buildings smaller than 100,000 sf will cost more per square foot and larger buildings will typically cost less per square foot.

| Retrocommissioning Activity | Cost |
|---|---|
| Scoping – preliminary (if required) | $1,000-$3,000 |
| Investigation (depends on energy calculations and project complexity) | $0.20-$0.30/s.f. |
| Implementation of Recommendations (labor and materials) | $0.05-$0.15/s.f. |

## 7. Benefits and Savings from Commissioning

Interest in reported savings may vary according to client needs. Utility companies involved will generally be interested in kWh, kW and therm savings, but the owner may

be interested in annual operation and maintenance cost reductions as well as energy savings. And in some cases water, sewer, disposal, or chemical treatment savings may also be calculated.

Benefits and savings of commissioning new equipment or construction include:

- Energy and O&M savings from improved equipment performance (not usually tracked)
- Smoother building turnover
- Identification of system operating and control problems – pre occupancy
- Improved system and equipment performance
- Improved indoor air quality and reduced liability
- Improved comfort and productivity
- Fewer maintenance problems and troubleshooting
- Extended equipment life

Retrocommissioning benefits & savings include:

- *Significant* energy and O&M Savings realized at relatively low cost – Based on recent data 2% to 49% utility cost savings (19% median) at paybacks ranging from less than one month to 4.6 years (median of 0.6 years), with substantial net positive cost savings. (Dodds et al, 2000)
- Identification of system operating & control problems – post occupancy
- Improved system & equipment performance
- Improved indoor air quality and reduced liability
- Improved comfort and productivity
- Fewer maintenance problems and troubleshooting
- Extended equipment life

# 8. Including Commissioning in PC Project Contracts

The opportunity for incorporating commissioning into a performance contract begins with the owner-contractor relationship. The owner should discuss new construction commissioning and retrocommissioning with the contractor before the contractor makes a proposal. At this point, the performance contractor is likely to state that they commission their projects. It is up to the owner to make sure that the contractor's definition of commissioning matches his or her requirements.

For commissioning new equipment, the owner should review the task list in Table 1 and the definition of functional testing from section 2.1 with the performance contractor. The performance contractor may claim that this level of commissioning is unnecessary and will add significant unnecessary costs. The owner must clearly stipulate the

commissioning tasks for the project so the performance contractor can provide an accurate cost estimate.

In the case of new construction or energy-efficiency measure commissioning, generally savings from commissioning alone are not estimated or included explicitly in the overall savings estimates, however the costs of commissioning may be included in the overall project costs.

For retrocommissioning the owner should discuss the concept of retrocommissioning as a stand-along measure and how much retrocommissioning they intend to include in the project and what their past experiences have been.

Since savings are more easily calculated for retrocommissioning than for new equipment commissioning, the retrocommissioning cost, savings, and payback can be itemized for each "finding", and summarized for the whole of the retrocommissioning project. Because the results of retrocommissioning may vary considerably, these can be estimated based on experience or historical published data and projected for the project in question prior to actual commissioning or equipment installation. Although the thought of this rougher approach to estimating savings might make some performance contractors nervous, there are ways to mitigate the risk. One option is for the performance contractor to modify the performance safety factor (cushion) of the retrocommissioning measures for the project economics analysis. Where a typical cushion would be 0.85, 0.7 might be more appropriate for example. Another way to mitigate the risk is to perform a retrocommissioning scoping study of the project in conjunction with the typical performance scoping or preliminary study to determine the estimated savings potential. Ideally, both reports should entail the same level of rigor and calculation methods. If the retrocommissioning scoping is performed first, then the results can be fed into the performance scoping or preliminary report.

With retrocommissioning incorporated into a PC however, the cost savings should be estimated in order to determine the economic impact on the project as a whole. Once the costs and benefits are known, these can be added to the other measures to determine the total package economics.

During the course of this analysis, the performance contractor will calculate the project equipment and labor, financing load, measurement and verification, overhead & profits design and other project costs over the life of the financing. The project is viable if it can support itself, that is, if the finance payment is less than the estimated energy savings multiplied by a safety factor cushion.

If the building owner or the performance contractor plans to finance commissioning costs (for new or existing equipment) as part of the overall project package, they must make this preference clear at the time that the preliminary analysis is presented. At this point in the PC process, an interested owner should request the inclusion of commissioning, or an interested performance contractor should present commissioning as an offering to the owner. The performance contractor who typically uses strategic alliances with various subcontractors and vendors to install and start up different types of equipment can subcontract a commissioning firm to carry out commissioning or retrocommissioning activities, or in some cases even perform these activities in-house if they are qualified.

# 9. Summary and Conclusions

Systematic quality assurance procedures are a good business practice for inclusion in performance contract projects for both the performance contractors and owners. Holistic commissioning, as a quality assurance process will result in better customer satisfaction, more referrals, fewer callbacks and improved energy performance and payments—all contributing to greater profitability for the contractor and owner. Commissioning is a recommended component of all performance contracts by the IPMVP. In traditional projects without a performance contract, commissioning has most often been performed by a party independent from the contractor. Because this preferred "independent" scenario may not always be easy to achieve, other acceptable scenarios exist where the commissioning provider is under contract to the performance contractor with conflict of interest management procedures in place.

Project scenarios using stipulated savings M&V for simple systems require the least rigorous commissioning and can be commissioned by the performance contractor with approval and oversight by the owner's technical representative. For simple measures or systems, using more rigorous M&V, generally, less commissioning oversight by the owner is needed. For complex systems, especially when savings are stipulated, commissioning should be conducted by an independent commissioning provider, when possible. When this is not possible, requiring the performance contractor to contract with an owner-selected (or at minimum owner-approved) commissioning provider is recommended. In these cases, reporting of all findings of the commissioning provider should be done directly to both the owner and the contractor.

Retrocommissioning of existing building systems can be performed at or near the time of a performance contract and either independent of or as a subcontract to the performance contract. Retrocommissioning combined with performance contracting has been shown to be an effective and even synergistic package with proper coordination between efforts that effectively captures the entire spectrum of savings available from low-cost operation and maintenance and control modifications improvements all the way through replacement of capital-intensive major mechanical equipment replacements. With this combination, the existing building owner can be assured that the maximum amount of energy and O&M savings possible has been identified and evaluated for their building, which together with implementation gives them assurance of total optimized building performance.

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